An alternative "Skippy-style" perspective on

How to Build a DIY Bio-Filter and Venturi for your Pond

by
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This document was created from the web site: http://leisure.prior-it.co.uk/pond.shtml

GARDEN FISH POND BIO FILTER

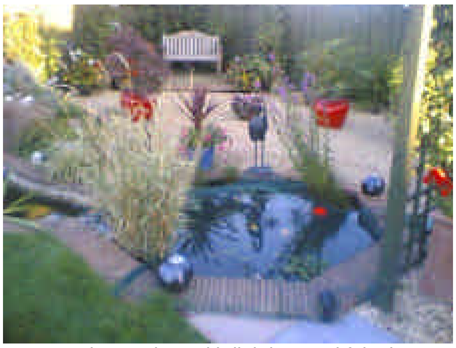
Introduction

Please bear in mind when reading this document that it was generated from the content on my web site, and even though I do update this document occasionally when I make changes to the web site, the pages of my web site are likely to be the more up to date. Also this book does not include all pages from my web site, since it is a continually evolving project. So for the latest information please refer to my web site.

What you get: *In this project I give some background into my pond, and the common "green pea soup" algae problem, my personal opinion of pumps and filters on the market and some modifications. I cover construction of a DIY BIO-filter with a simple venturi system and vortex chamber, and identify key issues in preventing algae, and also provide some useful resources and forums for research.*

Disclaimer: *I am not a professional, and my small pond is not specifically for Koi fish, this project is purely suggestions from my own experience and research. Some aspects involve modifications to equipment that could invalidate your warranty. I just enjoy trying things out, and judging by the number of people looking for similar information in fish pond forums, as one of them you might be interested in my ideas.*

Safety: Please be careful! If you have a young family, do remember that kids are fascinated by water. You really should think twice about building a pond if you are unable to supervise youngsters at all times. Tiny tots are fearless and don't understand the dangers of water, and it only takes a minute for a little person to drown, even in very shallow water. Having said that, our grand-children visit regularly, and with constant reminders they learn to be careful. But we **never** let the youngest ones near the pond without an adult right by their side.



Our pond, complete with lighting, and fake heron!

When we moved to a new house in 2001 we built a fish pond. My wife didn't want anything too big, while I on the other hand, had bigger ideas! Our garden pond was to be a home for a few goldfish (not a large koi-pond project), although as time has passed and the fish have grown, it has started taking on some aspects of the koi-keeper's concerns.

When we were planning the layout we started by using bricks on the lawn to mark out the shape and size. For about a month we had fun battling out against each other the actual size of the pond, which grew (me), then shrunk (wife), every other day, until we agreed to differ.

This is the fruit of our labours after 3 years. At first we just thought it would be mildly interesting, but in this time we have grown to love our fish, and we get many hours enjoyment maintaining and improving it, even more so as our little fish have grown into quite size-able whoppers!

We would even venture to say that from daily observation, and getting to know them, that our fish actually have different "characters". Maybe, as keen Scuba Divers who have seen many wonderful and beautiful forms of sea life, we have formed a respect and affinity with our aquarian friends in their own little garden haven.

For great fish-keeping communities visit my favourite forums at:-

- The American Water Gardening Society
- Koiphen Forums

They are very friendly and knowledgeable groups of people who will make you feel very welcome.

Fantastic fish ponds is an excellent guide on how to build and maintain your own fish pond. Learn The Secrets Of The Pros To Have a Fish Pond Water Garden That Will Amaze Your Friends!

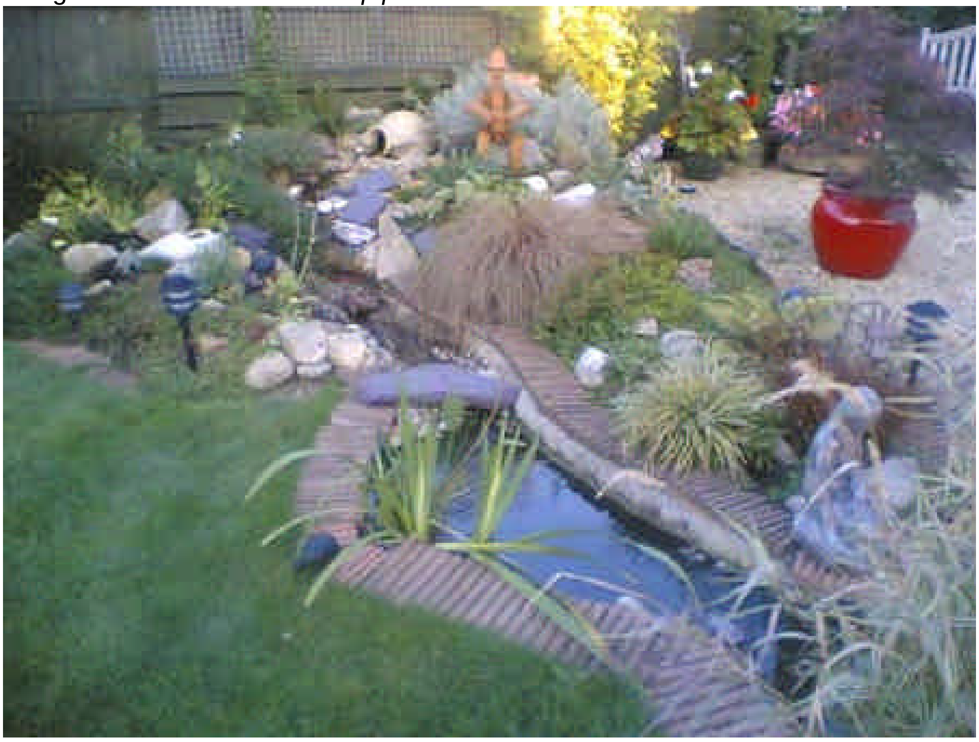
In a Nutshell

The original plan was always to have a "terracotta water urn" spouting water into the top of a small stepped waterfall, leading into a stream and "bog" area, then into the main pond.

We didn't want a prefabricated waterfall. Many of the fibre-glass or plastic waterfalls available were either not interesting enough, the wrong shape for the layout we wanted, or looked un-natural.

Most items used for our pond were bits and bobs that we found in various places, and the millstone style edging was a £50 batch lot picked up from the junk section of a local stone merchants.

We used high-grade pond liner to line the pond dug into clay (hard work by hand!), edged with substantial wooden battens to prevent cave-ins, and hold the weight of the millstone edging, and levelled using the old "*water in a hose-pipe with two funnels*" trick.



View of the "urn" at the top of the rockery, spouting into the waterfall, down the stream, through the bog-area, and into the pond.

There are 3 levels:-

- Deepest at 3ft. has a Hozelock Cyprio 240v 4000litres/hour fountain pump (modified by me to pass solids) sat on a couple of bricks, which powers a "water-globe" nozzle fountain (which doesn't foul up as quickly/easily as a fine water-jet fountain), and **also** pumps water up to the top of the waterfall via a Hozelock Bio-Force UVC Filter (although the UV bulb is no longer connected) and my **home-made "Skippy" style BIO-filter** (the construction of which is described in this project).
- Middle at 2ft to give some depth below the streams entry into the pond, so the fish can swim happily underneath, and the shelf can hold mid-depth aquatic plants, plus the shelf can be used to move the pump to a higher level in winter to allow warmer water to stay at the bottom.
- Shallow shelf at about 9-12 inches around the pond-perimeter for marginal aquatic plants (although we have discovered to our distress that herons love this sort of depth to stand and fish in!). We now have fine netting over the pond.

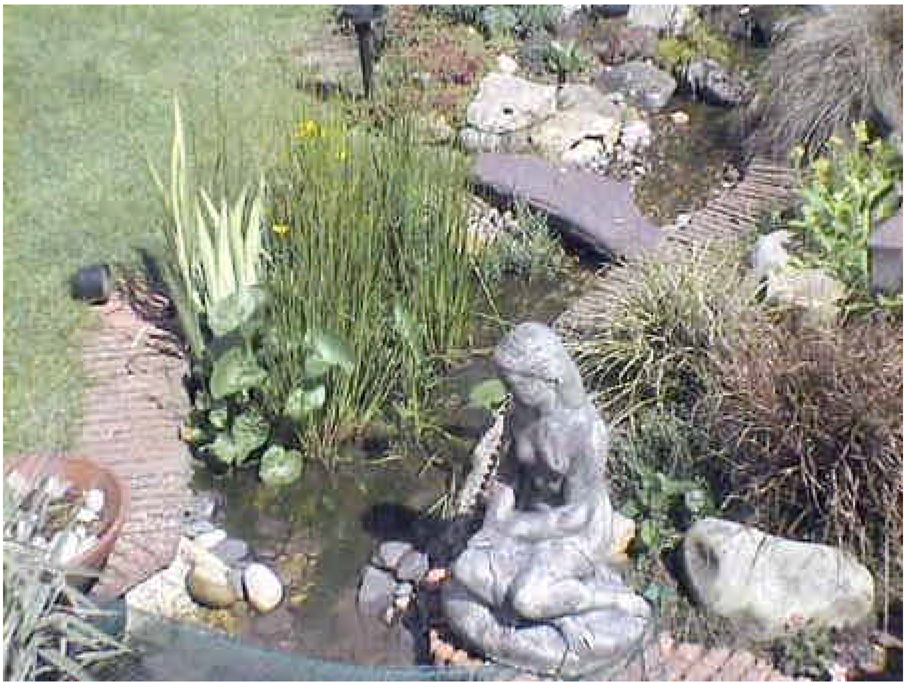
Building a Small Stream leading into the Pond

One of things that really makes a difference to our pond is the waterfall, little stream and bog area. When we built the stream we wanted something of our own, not a prefabricated fibre-glass or plastic unit. We used liner for ours, although some people fashion a waterfall out of concrete.

We wanted it to flow out of the urn, down 3 or 4 steps turning as it went, and then level out before it led, at a slower pace, into a bog area.

On this page I will tell you how to build a small stream for your pond, and the problems we came up against as we built ours. Although you will likely have some ideas of your own for your water features you will still need to consider several things.

Unfortunately I didn't take any photos at the construction stage - sorry - so I'll just have to describe it as best I can.



Waterfall

Water flows out of the Urn into the Waterfall

When we built the pond we ended up with a few tons of clay soil from digging the main hole for the pond. We used this to form the rockery and waterfall.

I dug the ground and built it up to form the steps for the waterfall area, and smoothed out the bottom (ours is fairly solid clayish soil which meant it stayed in the form I made it).

One of the key things with the waterfall, was to make sure the pond liner had plenty of overlap with each consecutive section. If you can, try to do it in one piece. See notes on this later on. Be sure you measure and then add plenty extra when you are buying your liner. If you don't allow enough you will have wasted your money!

We found it impractical to use one piece, because of the turn in the waterfall, and pushing the liner into the shape of the steps. Whatever you do, don't cut the PVC pond liner until you've got it positioned nicely and have done some testing by filling with water to see how it flows. And always leave plenty of overlap for making adjustments as it ages, in case you find certain areas settle and form overflows and leaks.

Make sure you exagerrate your levels to give plenty of depth to each step and plenty of height at the sides. If you don't you will end up with it being too shallow by the time you have put stones and gravel into each step.

Also angle each step backward, so that it becomes deeper at the back compared to the front. This will help create a nice pooling effect on each step, and prevents gravel from being washed down the waterfall.

Similarly make the vertical part of each step reach out further at the top than at the bottom to try and encourage the water to "fall" rather than just flowing downhill.

This is probably the most difficult thing to achieve with a "liner" waterfall, particularly if you don't have much force of water flowing. One made out of concrete can be fashioned to create very sharp steps, and therefore a more convincing water "fall". Fibre-glass waterfall units can be obtained readily from aquatic stores and combined with pond liner to create a stream if you prefer.

If you can, it is best to use **EPDM Pond Liner**, which is a very durable rubber liner.
EPDM is AQUATIC SAFE, it is a highly stable material that is formulated for safety when exposed to fish and plant life in a decorative pond.
EPDM is HIGHLY FLEXIBLE, it stays flexible in temperatures from -40° Fahrenheit to 175° Fahrenheit making it easy to install year round. Unlike other pond liner materials, it does not contain plasticizers that could make it become brittle with age and cause cracks or splits in the material, threatening aquatic life.
EPDM has DESIGN VERSATILITY, its flexibility provides more versatility in the pond design. Unlike preformed liners, it can be easily shaped to fit the unique contours of the pond dimensions, allowing a

more creative design.
EPDM is WEATHER RESISTANT, it has remarkable resistance to the harmful effects of ultraviolet radiation (UV), ozone and other environmental conditions.
EPDM has HIGH ELONGATION, it has high expansion and contraction characteristics that enable it to conform to objects in the sub grade. Should earth movement occur, rocks and tree roots could be dislodged beneath the liner, but EPDM's high elongation will enable it to stretch over such objects.
MINIMAL MAINTENANCE, it requires little or no regular maintenance once installed. However, if repair becomes necessary, it is easy to do without removing the liner from the pond with the EPDM repair patch.

You will probably want to put some heavy stones into the steps, because the liner has a tendency to unfold itself after you push it into the shape of each step.

Pebbles work better on a waterfall than small gravel which tends to get washed away.

Note the use of "gravel liner" to hide the black liner underneath. I think this gravel liner is quite important because you just can't put pebbles on the slopes and vertical surfaces of black liner to hide it.

Another consideration as you construct your waterfall is to strategically place a few large decorative "stepping stones" at the sides. Bed them in very securely. As well as looking nice, these are for you to stand on whenever you are maintaining the waterfall area, e.g. planting, clearing blanket-weed, working on the top pool, etc.


The Urn sits atop pebbles in the upper pool

Top Pool

In the very top where the earthernware urn spills water out, there is a seperate piece of PVC pond liner which forms a small pool that holds some nice big pebbles.

With this pool, the water is able to splash out into it and creates a nice sound (makes you want to go to the toilet, LOL).

Plenty of nice large rocks help hide the black liner, and hold it down at the edges. Again - Leave plenty of overlap!

Learning the Hard Way!

The first year was one of continuously ironing out the wrinkles:- adjusting the liner for the stream, searching for small (and sometimes large) leaks, and generally getting everything working nicely. The stream was initially done in 4 sections of liner from the waterfall to the pond. **One thing we overlooked with this method was capillary action which caused water to backtrack into open ground in the stream section because I hadn't allowed enough overlap**. Its amazing how such a minor thing can lose water so quickly, and when your water is metered by the local council, constantly filling up the pond with 50 or 100 gallons every couple of weeks can soon mount up the water-bill !

Large stones with pitted holes allow places for moss and plants to grow.
In spring birds love to steal the moss for their nests.

Eventually we ended up pulling out the entire stream and re-laying a single piece of pond liner. That did the trick. I would strongly recommend if you are considering building a stream that you make sure to have a single piece of pond liner, with plenty of overlap at the sides (its easy to hide too much extra under stones or plants, but you sure can't add it back on once you've cut if off!).

Although there are vinyl bonding adhesives which are supposed to be able to glue pond liner together, I would not trust them. Maybe its ok in the pond itself where there is little movement, but a stream is a living moving thing which settles, gets trodden on, expands, contracts and weathers in the sun, rain, snow and ice.

Keep the Water Flowing - Maintaining your Stream

Bear in mind that over time the stream will settle and the extra overlap at the edges will naturally get pulled inward and downward. For example in one or two places the millstone edging has settled (usually because people stand on it) and required lifting and building up again by shovelling some additional gravel or sand under the edge of the liner to raise the level again.

Also make sure you've got sufficient depth to your stream;

a) your kids will probably paddle and play in it
b) pets will like to drink from it (therefore step in it)
c) during the summer it will undoubtedly get blanket-weed build up in it

All these things will result in the stones or any channel that you have formed becoming levelled out or clogged up, which in turn will raise the level of water possibly sufficient enough to find grooves in your liner at the edges which then overflow into the surrounding ground. As mentioned above, **even the smallest leak, over hours and days will result in substantial loss of water from your pond**.

Evaporation in the summer does not account for a drop of 2 inches over 3 or 4 days - it means you've got a leak!


The stream bubbles under the slate bridge

Once finished and bedded in, every couple of weeks examine your stream for little pebble dams that might be causing a raise in water-level, clean out too much blanket-weed (I think some blanket weed is nice, and helps achieve a natural look as it sways slowly in the current), and push the pebbles towards the sides again to create more depth for the water to flow in the middle of the channel.


Sunlight shimmers like gold in the moving water

Pampering Your Bottom

Another important thing with a stream when you are building it is to give it plenty of padding underneath the liner, with lots of sand and/or old blankets. Most people recommend sand, but I think some material such as blanket will stay in place (sand might get washed out by rain), and also I think it might help deter creatures such as voles or moles from tunnelling into your stream.

Never put sharp stones or objects in the stream. The temptation for kids and pets to mess about in the stream is too great.

You're not concerned about the kids or pets!

What I'm talking about is their weight will push any sharp objects through the liner, puncturing it, and you will <u>never</u> find where the leak is! You would have to re-lay a new stream liner again.

Also explain to your children that pond liner does not like sharp sticks, football boots, toys, etc!

You Gotta Do A Bridge

Another thing that I added was a bridge. Here it is in the form of a large chunk of slate laid across the stream. I've also seen some very nice miniature wooden bridges which I've been tempted with, but they can be quite expensive, and wifey thought that the size of our stream didn't warrant a large wooden structure, so we went for the slate instead.


Marsh buttercups, cress and reeds thrive in the bog area and help
create a natural veggy filter to keep your water clean and clear.

For some reason kids just love to cross the stream, so I prefer them to step on the bridge rather than in the stream where they might puncture the liner. It also helps us adults take a short cut when we are gardening the surrounding rockery and plant beds.


A very early photo of the bog area before it was established

Two Layers Are Better Than One

One thing that helps in this area is to consider two layers and types of garden pond liner;

1) a good thick strong black pond liner at the bottom (preferably EPDM Pond Liner), this gives the main waterproof membrane,

2) gravel liner

I'm not sure what the proper name is for it, but basically its a very thick butyl or PVC plastic (black on the back, grayish/white on the front). It has very small gravel glued/melted into the plastic. Being stone/gravel, it gives a more natural look at the edge of the stream.

It can be quite expensive though, so rather than laying it the complete width of the stream, I cut it into strips about 18 inches wide and laid it just at the edges of the stream. The black liner bottom will become covered with smooth pebbles and gravel.

Tip: When cutting the gravel liner, cut it from the back side with an old knife that you don't mind getting blunted by the little stones.

Close-up of the sides where the black liner is covered by the (expensive) gravel coated plastic.

Now you have double-protection to a certain degree from the bottom layer getting punctured. Finally, put a layer of fine gravel on the black bottom liner then also lay rounded pebbles in the bottom, or large flat stones, slate and anything else that helps achieve a natural look.

Let Nature Do Her Work

The main thing to remember that is to enjoy it and not rush the job. It takes a good year or two to get a rockery established and the stream looking good with plants growing over the edges, etc. As long as you get the basic shape and size right to start with, you will continually be making little adjustments forever after, moving a rock here or there, selecting the right plants, and so forth. This is where my wife's gift of green fingers makes it look lovely. It is definitely a passion that we now both enjoy and it gives us something fun to do together.

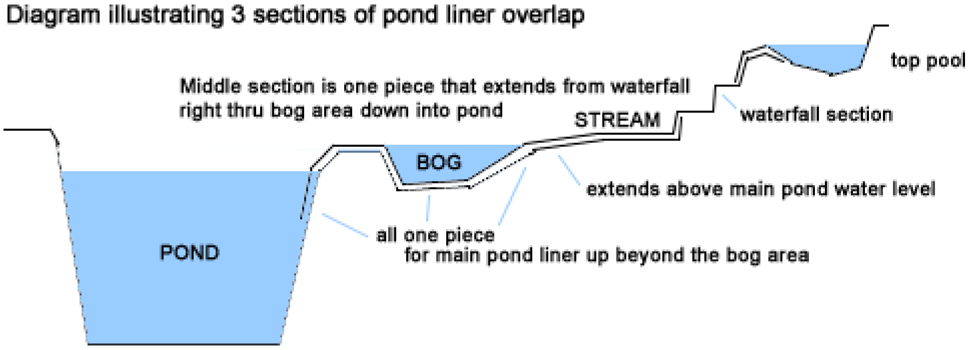
A year later and the bog area looks great.
Various baubles and low-voltage garden lights complete the setting.
It looks wonderful at night too with its underwater lights.

More About Overlapping

Where the bog area runs into the pond, the normal level of the pond water would be a couple of inches below the lip of the bog area. The PVC liner of the main pond and the liner of the stream are seperate pieces, but there is plenty of overlap.

The liner of the main pond extends up and out to form the whole bog area as well, and then up the stream a little way (to prevent capillary action), while the middle pond liner section forming the waterfall and stream also goes right down through the whole bog area, and overlaps into the pond. I'm talking of about 5 or 6 feet of overlap, so that both pieces of liner form the bog area! This is shown in the following illustration. Likewise the top pool liner overlaps the first step of the waterfall section.

Its double-protection. **You have to be sure that this area is able to contain its water with no leaks**.



Again if you can actually do the complete pond and stream in one piece of liner that will guarantee no leaks. It depends on the length you want your stream to be, and also whether you have already built your pond as to whether you can do it with one piece.

All I'm saying is you absolutely MUST get this right at the start of your project, because you don't want to be messing about with it later on.

Making the Bog

Also when fashioning the bog area I dug it deeper than the step which actually leads into the pond. This was so that we could lay a sufficient depth of pond-soil for the bog plants to grow in, without the soil being washed into the pond by the flow of water. Do NOT use ordinary soil. Get proper pond soil which is a lot more loamier and heavy and sinks to the bottom and stays there.

The River Flows Into The Sea

At the threshold of the stream going into the pond I also have a large flat piece of slate sat atop of the liner, which the water flows over before entering the pond. This looks nicer than the black liner, its also more attractive than the gravel liner, and more importantly it helps to prevent soil being washed into the pond and the water picks up a little bit more speed as it flows over the slate before it enters the pond.

One problem we encountered at first and which requires a bit of messing about with is that the water prefers to flow under the slate, rather than over it! Putting gravel and soil at the bottom edge of the slate helps to block it, and over time it silts up with muck and seals naturally.

Another ponding friend suggested that I could have used a can of plastic foam (like the kind used to fill cavity walls) to create a barrier underneath before bedding the stone and this would have helped prevent this problem. If I ever have to uproot and re-lay this step, then I will most likely do as she suggested.

The large flat piece of slate creates a kind of dam, to prevent soil and silt being washed into the pond from the bog. Pebbles at the sides help narrow the entrance into the pond creating a slightly faster flow. The fish like to push their heads out of the water facing up the stream to see what morsels of food might be washed out of the marsh to them!

Plenty of Piping

To feed the water from the pump in the pond, up to the bio-filter and then the top pool, I use 25mm flexible hosing which runs beneath the millstone edging of the stream. This means the pipework is protected, yet it is simply a matter of lifting the edging if ever I need to replace it.

When you cut the pipe to fit your equipment at the top of the stream, for example to go into flow control valves or the pre-filter, **make sure you leave plenty of extra**.

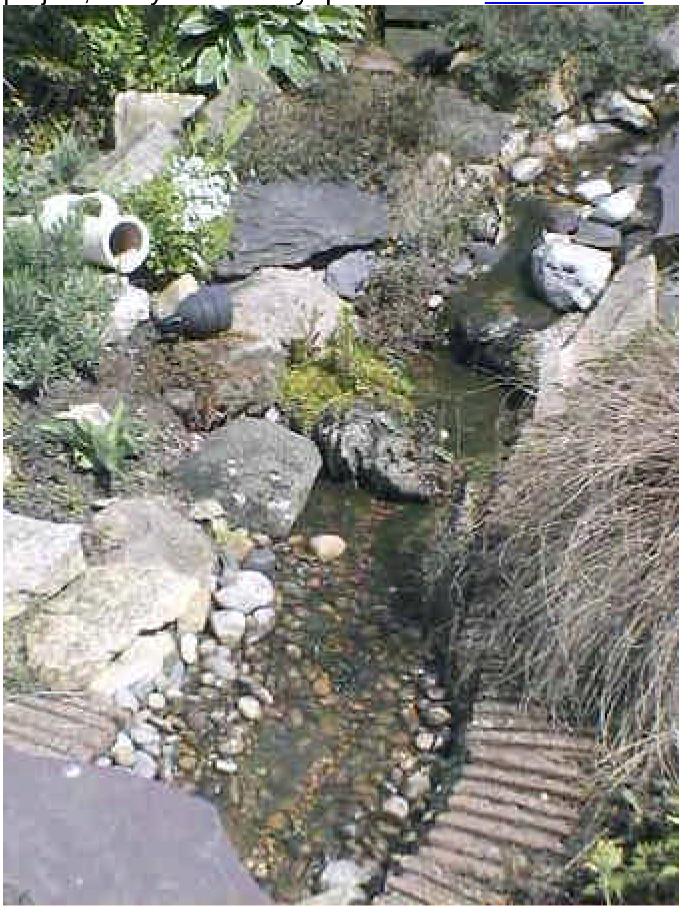
When I initially was using the Hozelock Bio-Force UVC filter (before I got fed up with it blocking and requiring cleaning all the time and replaced it with my own homemade bio-filter), cleaning it required unclipping and removing the top, but of course because the flexible pipe was attached to it, this meant the plastic pipe was constantly being bent back and stressed.

Now you might think "Isn't that what flexible piping is supposed to do?". Well yes - but in the winter when the plastic is cold, and in time due to the constant bending, one day the piping cracks and you're suddenly pouring gallons of water all over the place. To fix it you have to cut the pipe back to a good point, but you can't do that if you've cut it too short in the first place!

So please bear this in mind if you are thinking of using a filter unit that involves the pipework constantly being flexed.

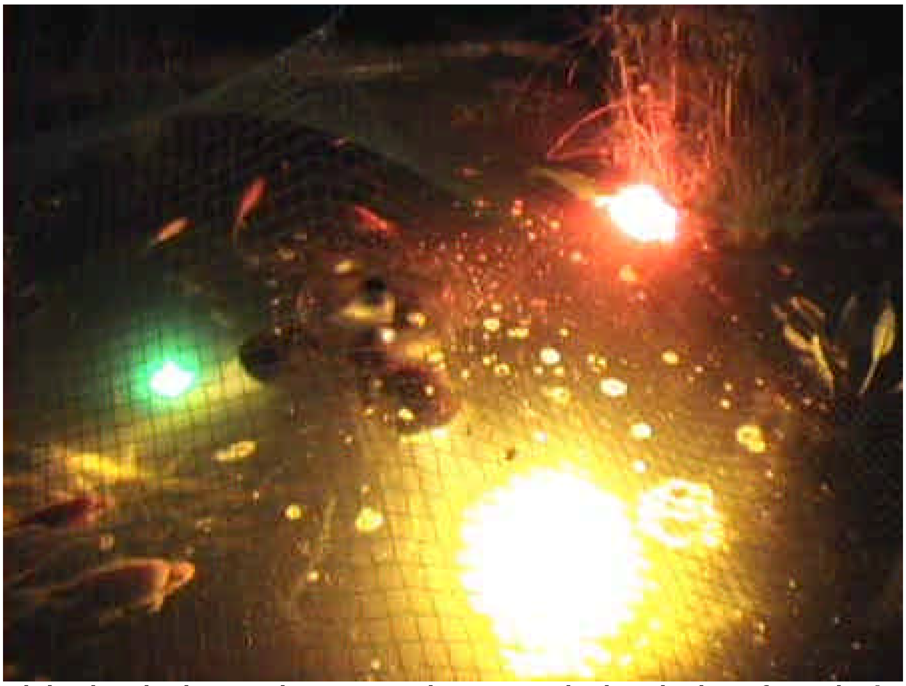
Conclusion

Well that's the stream! We hope this gives you a few ideas, and would love to hear from you about your project, or if you have any questions.   email Leisure

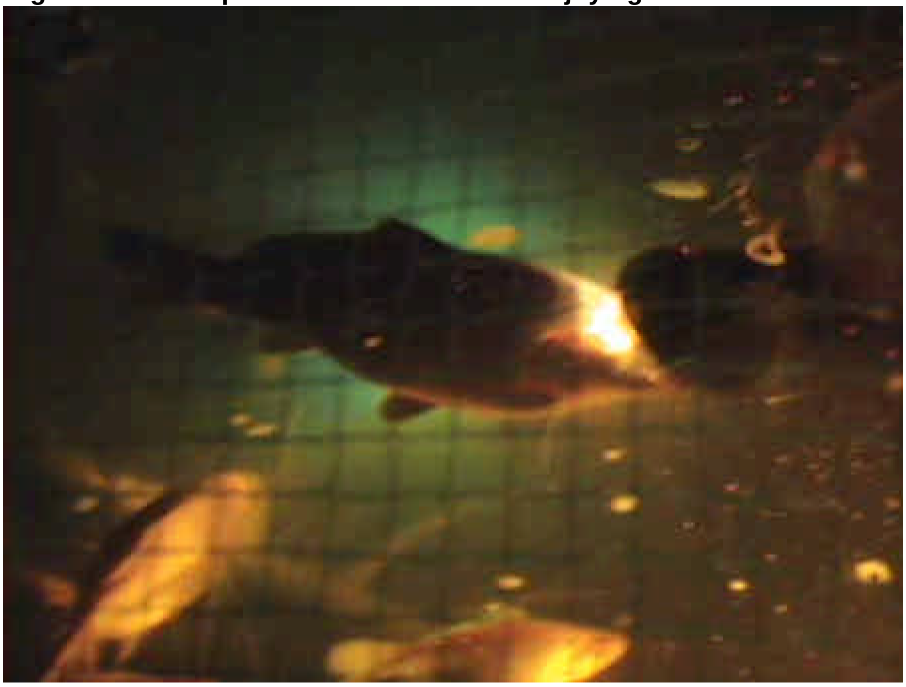


Lights placed strategically light up the waterfall at night.

It's well worth the effort. A stream and bog area attracts so much wildlife; we get frogs, dragonflies, water-boatmen. Also its a delight to see wagtails and blackbirds come to wash in the stream. On some occasions when heavy rain has raised the water level in the pond to overflowing, the smaller fish will swim up the stream to explore the bog !



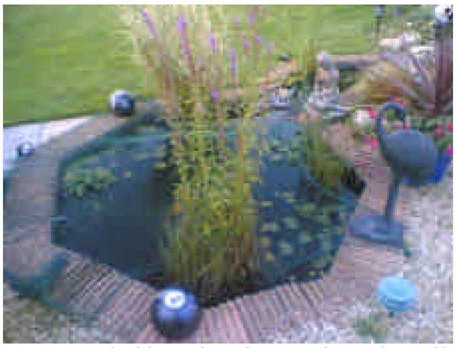
Night-time in the pond. Jaws can be seen enjoying the heat from the lamps.



Green Pea-soup

During the second year our fish had babies, and the adults were growing at an amazing pace. We started with 12 fish, a mix of goldfish, shebunkins, and ghost-koi, all of which were about 3 inches or smaller. Now the ghost-koi look fantastic and the biggest is about 12 inches long and looks very stocky and chunky. I'm sure he'd make a good dinner (only joking).

For the first year the water was lovely and clear, even in the summer, and we had good cover to provide shade from the marginals, like lilies, water hyacinth, and "Fairy Moss" - that red-leafed surface cover weed that can take over the pond and you end up scooping out handfuls of the stuff. Also in the boggy area of our stream we had a good variety of bog-plants; Marsh Marigold, Horsetail Rush, Water Musk.



The main pond, now covered with netting since we lost 2 beautiful carp to a heron.

But, in the second year (Summer 2004) things suddenly started going wrong.

Three things seem to be the culprit:-

1. The fish were much bigger, and eating more, were therefore excreting more.
2. Even though we put more of the Fairy Moss in the pond to get more cover to keep out the sun, it didn't survive, we think the fish were eating it(?).
3. The yellow-flowered Water Musk had pretty much taken over the entire bog-area, and so **we had a mad fit and removed ALL of it!**

Ooops! **Within about 2 weeks the water went a pea-green, taken over by fine water-born algae**. We couldn't see below about 4 inches, any deeper and the fish could only be made out as dark shapes passing below.

In hindsight we now realise that the plants in the bog-area, with their massive root network, were acting as a wonderful natural "veggy-filter" to eat up nitrates in the water, hold back any crap being pumped out of the pond coming back down the stream, and provide a home for bacteria that was helping the whole "balance" process.

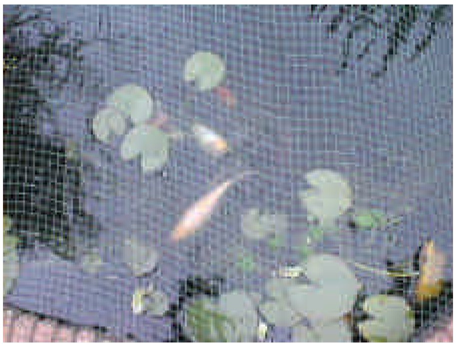
When we designed our pond, waterfall, stream and bog-area, we didn't really appreciate what a clever design we had given "nature" to work with.

And we had just messed up by removing the most vital part of the cycle. A <u>natural</u> <u>vegetable</u> biological filter.

Initially we didn't figure out why it had happened. At about the same time the fish had been traumatised by the heron eating two of the larger fish, and we thought the water was cloudy because they were stirring up the bottom silt to "hide themselves".

I was also starting to get very fed up with cleaning my Bio-Force filter literally every 2 to 3 days, and having to remove the Cascade water pump from the pond every week because that too was getting clogged up, mostly by blanket weed.

I knew that sunlight was going to be a major cause of the algal-bloom, but I was starting to get concerned about the state of the water and the health of the fish, the water at times was almost looking "black", and so I started my quest to learn more about what was going wrong and how to resolve the problem.



Introducing "Skippy"

Everywhere I looked there seemed to be plenty of remedies in the form of expensive solutions and additives which promised to eradicate the blanket weed algae that was fast overcoming the pond, and other remedies to remove the water-born algal bloom. However I was already trying these to no avail.

It seemed like a threshold had been passed where the algae was winning hands-down.

I had been toying with the idea of buying a new bigger better pump, and getting a better filter (although at this point had no idea what kind), but all this seemed yet more expense given that I had already upgraded from a Hozelock Cyprio 24v Low-Voltage 2000litre/hour pump to the 240v 4000litre/hour model earlier in the year, and also purchased the Bio-Force UVC (Ultra-Violet Clarifier) 2200 Filter, which now I didn't think was man enough for the job (even though the performance ratings suggested it should be sufficient).

I also felt that the Ultra-Violet clarifier was just a gimmick because it didn't appear to be having any effect on removing the algal bloom, even though my pond at about 400 gallons is by no means large as compared to some peoples. [In fact 2 months after finishing my bio-filter I have clear water and the UVC bulb is not even connected!]

So before making any impulse purchases I felt it would be wise to do some research into the best solution. I started doing some surfing around all kinds of pond-related web sites, most of them obviously trying to sell their stuff, and many of which didn't appear to give the answers I was looking for.

Now before going any further into my project **I would like to show you a web site which I thought was a breath of fresh air** amongst all the technological gobbledy-gook being pushed at me by the myriad of web sites whose sole purpose appears to be providing "good advice" with the ultimate aim being that you buy one of the multitude of different makes of pumps, filters and other accessories.

Skippy's is the site that gave me the inspiration to have a go at building my own BIO-filter. And the most wonderful thing is it explains all about "*freakin magic*"!! <u>You</u> **NEED** to know about **Freakin Magic** in order to understand ponds (you'll see what I mean if you don't already know), in fact you'll learn about **Nature and LIFE**! In fact even for experienced pond keepers, it makes a great read - the emphasis is on helping you understand how to work <u>with</u> Nature to create balance, not against her.

Skippy's then tell you how to build your own DIY vortex/settlement-chamber based BIO-filter. Its a great site but for one thing. I don't think they make it clear enough that you need to **PRE-filter** the water going into the BIO-filter (maybe I missed something!). For a novice like me I got the impression their bio-filter was able to do everything. It wasn't until after I had built my basic bio-filter based upon their ideas, and then later read in their associated forum about other newbies who similarly misunderstood the need for PRE-filtering, that I made some changes. (I also emailed them about it and they confirmed I was right).

Anyway, this project is my own take on the Skippy Bio-Filter. Once you've read their web site (and I strongly recommend you do), if you are interested **come back and see how I've done it** (and implemented a simple venturi too - a mechanism to mix air into the water with no moving parts), and also where to get media for your Skippy filter if you're in the UK (Skippys is a USA site).

So here it is ...... **Skippy's bio-filter** - I suggest you start first by reading this page, closely followed by this page to learn about Freakin Magic, then go to this page for their Bio-Filter construction.

Remember to come back here! :-)

Now I will show you what I have actually done, and why.

If you have any comments or suggestions about this project please contact us: email Leisure

DESIGN CONSIDERATIONS FOR A DIY BIO-FILTER FOR YOUR POND

Right. In this section I get down and dirty with some mathematical calculations based upon advice given at a number of Internet resources during my research. Don't worry. Skip to the pictures in the Build Section if you just want to see how I built it, but you might find this design section useful to help your understanding of the processes involved, and what is generally considered necessary in the design of a biological filter.

This section covers the following topics:-

- **Overview & Design Points**
- **A Quick Recap**
  - **Biological Filtration and the Nitrification Cycle**
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Overview and Design Points

If you're done at the Skippy site after reading the previous section, you now have a pretty good idea of whats involved in building their Skippy bio-filter, and how it all works. This picture is of their basic Skippy filter "in the raw". Hmmm. I think "functional" is the word! Well, it's not so bad after a bit of hiding!

A Skippy Bio-Filter

Where did it go?

I like the whole idea behind the Skippy design. However I had some ideas of my own:-

- My pond is not massive (about 400 gallons), so I didn't think I needed a tank as large (or ugly) as a "Rubbermaid" used for the Skippy filter. Please remember that I am not a professional Koi-keeper! I don't need a massive filtration system, I just want to improve the water quality for my small pond.
- Generally a Skippy filter is situated at the top of, and is effectively part of a waterfall, with its large flange outlet (see above picture), the water literally flows out and down the waterfall (with rubber sheeting around the flange to prevent water leaking behind any rocks which form the waterfall). To accomodate this size of tank into my already built rockery simply was not practical, and I wanted a design with flexible pipe to put the water where I wanted it - in the back of my terracotta urn.
- I particularly liked their "vortex" design, where the pipework creates a swirling motion in the base of the filter, but a "Rubbermaid" is oblong. Using a cylindrical tank would be better to maintain a smooth swirl in the bottom.
- I wondered whether I might find something that looks nicer, and could "blend" into the garden better.
- Rather than having a drain outlet in the side, I thought that a drain exiting vertically down out of the base would help remove filtered solids more efficiently. A Rubbermaid tank has a small outlet in the side, near the base, which is fine for draining just water, but not great for getting gunky muck out of a bio-filter!
- After reading up on "venturis", I wondered whether a venturi dedicated to aerating the filter itself would improve oxygenation of the aerobic bacteria in the bio-filter.

Well, here is a picture of my working bio-filter in position (before the venturi was fitted). I find this is sufficient for my 400 gallon pond.

I suppose a serious koi-keeper might laugh his socks off! Thats fair enough, and I admit I am a bit eccentric but I like to try out my own ideas. In time I might paint the pipework a terracotta colour so its not so garish, and grow some more plants both inside it (to help filtration), and around it.

I might also add at this point that by building this filter myself I did not save money! I think I must have spent around £100 by the time I had finished experimenting and getting all the parts together. If I had known exactly all the parts I needed right from the start it would have been cheaper, more like £70.

I could have bought an off-the-shelf prefabricated product of similar size for £50, but I don't think I would have enjoyed the challenge as much as doing it myself!

A Quick Recap

Before we continue lets recap on what we're trying to achieve;

Biological Filtration and the Nitrification Cycle

A biological filter is quite simply the heart of a koi pond. It is not essential in small fish ponds, but the more fish you stock, the larger they get and the more they eat, so the need for a bio-filter becomes greater. The pond gets to a point where it needs a "sewage farm". It's purpose is to convert the waste matter produced by the koi from harmful ammonia into less toxic waste.

It is less important to remove solids particles from water than it is to process nitrogen, so if there is to be a compromise between mechanical and biological, err on the side of biological.

In other words, it is much better to allow particles below a certain size to escape back into the pond, while converting a great deal of ammonia to nitrate, than it is to catch every little thing down to a micron or less which in the process would slow the water down to the point where the bacteria have a hard time living (because they're not getting enough oxygen).

The bacteria that convert ammonia to nitrate for us are among a class of bacteria that you may have heard of before. They are the so-called, “nitrogen fixing” bacteria. This means that they take nitrogen that is unavailable to plants in its ammoniacal form, and make it available to plants in an oxidized form.

These are the same bacteria that live among the roots of leguminous plants. Without these beneficial bacteria, life as we know it would cease. So be kind to your bacteria. What they need to survive is a large surface area, chemically inert medium and a ready supply of fresh water. **They depend upon dissolved oxygen in the water to live and to do their job**. As soon as the water flow is stopped, the oxygen in the filter becomes finite, and eventually gets used up. The ultimate result is that the bacteria die, and you have to start over.

Some people use both mechanical and biological filtration, and some of the new commercially manufactured filters available do this. In the first instance, many people are tempted to install a canister filter (pre-filter) ahead of the biological filter, thinking that they will extend the life of the media used in the bio-filter by catching all of the particles that would eventually clog it up. They are correct, of course, but they wind up being slaves to the canister filters in an effort not to destroy their pumps, which have to work too hard to push water through the pre-filter canister.

It is better to merely use the bio-filter and to maintain it well.

Putting the canister after the bio-filter is a good idea, but the same problem arises, just less often.

Several types of bacteria are currently available to you, each with its own specialty. It is important to start out with a good supply of beneficial bacteria so that you minimize the green water stage of pond establishment.

There are 2 types of bacterial species that colonise the biological filter media. **Nitrosomonas sp. bacteria** which oxidize ammonia to **nitrite**, and **Nitrobacter bacteria** convert nitrite to **nitrate**.

Ammonia

Ammonia ($NH3$) is produced by fish (and particularly koi because they are fat greedy chaps!), as part of their normal metabolic function and is excreted from the gills. The amount of ammonia produced is directly related to the amount of food they eat. Approximately 3-4% of normal 30-40% protein level koi food will be excreted as ammonia, i.e. for every 100grams of food 3-4grams (3000-4000mg) of ammonia is produced.

Koi exposed to unacceptable levels of ammonia risk damage to gills, eyes, fins and skin which can result in them being susceptible to secondary bacterial infection.

Using standard drop type tests kits <u>any</u> ammonia reading is considered unacceptable and remedial action should be taken.

Nitrite

Ammonia is oxidized by the Nitrosomonas sp. bacteria in the filter to produce nitrite ($NO2$). Whilst it is not considered as dangerous as ammonia it can still do serious damage to your fish. High levels of nitrite are likely to stress your koi leaving them susceptible to secondary infection. As with ammonia, target levels should be that nitrite is undetectable.

Before the fish pond filter can efficiently remove ammonia and nitrite from the fish pond water, it must first become fully colonized with nitrifying bacteria. This can take some time and is a process known as fish pond filter "maturation". Each time a fish is put in the fish pond it will add to the total amount of ammonia being produced. The ammonia level in the fish pond will therefore increase slightly. Because there is more ammonia for the bacteria to utilize, they start to multiply until there are enough to use all of the ammonia being produced inside the fish pond. The ammonia level in your fish pond will then fall back to zero.

Nitrate

As the ammonia level falls, the amount of nitrite produced by the bacteria in the fish pond filter will start to increase. Therefore, the level of nitrite in the fish pond will rise. The increasing nitrite level means that the bacteria that break it down can start to multiply in the fish pond filter until, as with the ammonia, there are enough to use up all the nitrite that is being produced. The nitrite level within the fish pond can then fall to zero. As this occurs, the nitrate level increases.

Conversion of nitrite to nitrate ($NO3$) is the final stage of the nitrification process. There is debate as to the possible problems that elevated levels of nitrate may cause. Indeed some koi keepers have high

Nitrate and it causes no problem at all. **High nitrate may also attribute to green water (phytoplankton) and blanketweed growth** however the two do not always go hand in hand. The green water problem can get worst when you clean the biofilter and make water change outs, due to the reduction in bacteria.

The bacteria also produces a certain phytoplankton-killing enzyme. As algae starts to grow in the bio-filter, or on the walls of the pond, the bacteria loves to feed on this algae, and as it does so it releases the enzyme into the water.

Green water is a pain for many reasons. Ultra Violet Clarifier lights will kill single cell phytoplankton algae that cause green water, and when dead they clump together and can be removed by the filter. However there is sometimes a concern expressed that passing water through the UVC also kills beneficial bacteria. Note that a UVC does not get rid of blanketweed.

The Skippy site teaches us that we should try to achieve "balance" in the pond - don't fight mother nature. By use of the bio-filter and other larger plant forms you starve the water of Nitrate, so that the algae has no food, and is therefore unable to grow, while at the same time the bacteria create the enzyme which kills the phytoplankton. Its a double-edged sword in this battle.

Some Theory and Maths

During my research I came across a very complete and excellent resource by Terry Cusick,Third Alternate AFKAPS Rep and Certified AKCA Koi Health Advisor at FishDoc.co.uk to whom I extend my thanks, and from which a number of extracts have been used to compile this section of my project. I strongly recommend reading the complete article since the site provides a very thorough explanation of the considerations when designing filtration systems for ponds to ensure healthy fish.

Essentials

Humans convert ammonia into urine, whereas fish simply excrete it continuously from their gills into the surrounding water. Normally in a river or the sea it is diluted by thousands of gallons of water to render it harmless. But nobody told Mother Nature about koi-keepers and their ponds, where ammonia can build up to a dangerous level due to the large number of fish in a small volume of water.

A koi pond has to deal with two types of pollution; solids waste and dissolved waste from solids. Therefore it is essential to remove the solid wastes from the water before they have a chance to dissolve. If we can do this we gain; better water quality, fewer dissolved pollutants and ultimately less fish health problems.

Once the solid wastes have been collected, it is important that they are flushed out of the system regularly, before they get the chance to decompose. In summertime this could be as often as twice a day. This means that any settlement chamber incorporated into the filter design will need to have a drain to allow easy flushing to waste.

- It doesn't matter whether the solids decompose in the pond or the filter - the result is the same - polluted water!
- To maintain good water quality it is essential that solids are removed from the pond and filter before they have time to pollute the water
- Any trapped solids must be removed from the system on a regular basis, otherwise they will simply decompose and pollute the pond. They will also encourage high levels of opportunistic bacteria.

For good filtration and water quality very little solid waste should be allowed to enter the 'biological' section of the filter. To restate the point made previously; the more effective the settlement area of the filter at removing solid waste, the lighter the load on the following biological section - provided, of course, that trapped waste is removed before it decomposes.

This entails:-

- Regular maintenance to keep the biological area clean and free of mulm,
- Reducing the level of dissolved organic compounds by effective settlement/entrapment, together with regular cleaning of the settlement area.
- If we can remove solids from the system before they decompose and at the same time keep the biological section of the filter fairly clean we will;
    - Encourage a vigorous growth of nitrifying bacteria
    - Reduce the load on the biological section

Do you see a repeated theme here? Cleanliness is the order of the day!

Design Considerations

When building a filter it is suggested that either;

- the filter surface area should be approximately one tenth that of the pond; or,
- that there should be a pond turnover rate of once every 2 to 3 hours.

How much surface area?

Nearly all types of filtration system rely on "attached-growth" processes in which a bacterial slime layer or biofilm - comprising of bacteria, algae and often-larger invertebrates, such as worms and snails - forms on the media. Micro-organisms present in the biofilm 'feed' from the water as it flows past. So, as a first approximation, the amount of biological activity will be determined by the **amount of available surface area** for bacterial colonization. However, in practice this available **specific surface area** (**SSA**), as it's called, is rarely a limiting factor since most filtration systems are large.

Bacteria will thrive on almost any surface and the particular choice of medium has very little influence on their growth.

Obviously, if you had just a square piece of material measuring say 1m x 1m this would give a total area of 2 square meters (because both sides are available for bacterial colonization assuming almost zero thickness). Even this small area could support millions of micro-organisms, attached in a slimy biofilm. But typical filter media have a far greater **SSA**.

For instance, gravel has an available surface area of about 100 to 200 square meters per cubic meter (100-200 m2/m3). This area is also often expressed as the **Surface Area to Volume Ratio**, for example **200:1**.

And other, more specialist media can have significantly more surface area as indicated in the table to the right.

So you can see that even a small amount of filter medium provides a potentially vast SSA for bacterial colonization.

Each square meter of biologically active surface can metabolize nearly one gram of ammonia per day, dependent on temperature, and given that most ponds will usually be producing fewer than 60g of ammonia per day, the amount of SSA required is really small - and "not a lot of people know that", as Michael Caine might say!

Media	SA to V Ratio
Flocor	200:1
Stone(2cm)	70:1
Kaldnes K1	800:1
Bio Block	700:1
Bio Balls	550:1
Bio bale	800:1
Hozelock Cyprio Media	180:1
Scouring Pads	300:1
Siporax	10,000:1
Ceramic	1,000:1
Fine Foam	1,000:1
Coarse Foam	200:1
Medium Foam	600:1
Trickle Media	200:1
Bio rings (5/8in.)	340:1
Bio rings (1in.)	210:1
Bio rings (1.5in.)	130:1
Compac 3	280:1
Hair Rollers	150:1

If we based filter sizing on the basis of SSA alone, filters could be incredibly small -perhaps only the size of a shoe box! However, there are other factors to consider....

Is void Important?

The void size or empty space within a filter medium is important in determining the right filter size and efficiency. Void size is a measure of how much of the medium consists of empty space. If we consider sand, for instance, each particle has a large surface area in relation to its volume and the total SSA per cubic meter of sand works out at thousands of square meters. Despite this enormous SSA, sand would make a poor filter medium because the small particle size would soon lead to blockages and subsequent 'tracking' as water found the 'easy routes' round the medium. And, of course, because of the dense packing, any flow through the sand would be very slow. So, despite its massive surface area, once compacted and blocked the amount of surface area exposed and the volume of water that could be treated per hour would actually be quite small.

There is another important disadvantage of a medium like sand - **retention time**, or the amount of time the water spends in contact with the biofilm. It is obvious that if we wish to avoid blockages and tracking, some void space in the filter medium or media is desirable. If we consider a medium such as gravel, although its larger size yields less SSA it is less prone to tracking and blocking. And specialist media such as filter matting, plastic or sintered glass have both a large SSA and a generous void space. In fact, many of them are more than 90% void or empty space! This makes tracking and blockage almost impossible.

What about cleaning?

Another important consideration - which becomes more important the longer you keep koi! - Is ease of cleaning. In the early days of the hobby, part of the novelty lies in spending weekends cleaning and vacuuming. But after a while, strangely, it seems that there are more pleasurable ways to spend a sunny Sunday. And with gravel and other granular media, it really isn't much fun trying to clean several tons of the stuff! Compared to gravel, cleaning lightweight media is a delight. Obviously, regular maintenance is somewhat easier if each filter chamber has its own bottom drain but, even so, ease of maintenance has to be a major consideration in the choice of filter medium.

The three major factors affecting our choice of filter media are:

- Specific surface area
- Void space
- Cleanability

Bio-Filter Water Retention Time

Broadly speaking, the effectiveness of biological filtration is improved the longer the 'polluted' water is held in the filter - i.e. the longer the **retention time**. The most time-consuming process in filtration is the breakdown of dissolved organic carbon compounds into simple inorganic compounds. These compounds are ultimately incorporated back into living organisms. This complex chain of processes is not instantaneous and will, even under ideal circumstances, take some time. If insufficient filtration time is available, intermediate products will be pumped out of the filter back into the pond. This is clearly undesirable and rather defeats the object of having a filtration system. Indeed, this may well be the reason why excessive alga growth occurs in some ponds, with the filter merely producing an endless supply of plant nutrients!

So for how long should water be retained in the biological section?

This depends on how polluted the water is in the first place. Certainly, industrial water treatment plants - which handle much higher levels of pollution from sewage etc. - would retain water in the plant for many hours before it was deemed sufficiently clean to return to the nearest water-course.

Given that pond water is likely to be only mildly polluted, a retention time of 10 minutes, possibly longer, will usually suffice.

The more polluted the water is, the longer it needs to be retained in the filter. Most koi ponds will require a retention time of at least a few minutes.

How do you calculate the retention time of your filter?

Doing the Maths

This is determined by the **flow rate** and the **volume of water in the filter**. If water output from the filter is 2,000 gallons/hour and the filter contains 500 gallons (when full of media) of water then:

filter retention time = filter size / pump rate

so, in our example:

retention time = 500 (gallons) / 2000 (gallons per hour flow rate) = 0.25 hours (which is 15 minutes).

So a given sample of water will take 15 minutes to pass through the filter and back to the pond.

In the above, the filter capacity represents the amount of water in the filter - **not** the physical size of the filter, which will be greater.

The **retention time** and the **size of the filter** will depend to a very large extent on the type of filtration medium used.

A solid medium with low void space such as gravel will occupy much more filter space than large-pored, lightly packed media and therefore leads to a lower retention time.

More calculations!

Using our same example of a 500-gallon filter. If we now nearly fill it with gravel, the volume of water it will hold will be reduced substantially - maybe to as little as 150 to 200 gallons. Using the above example, the retention time of such a filter would now become;

200/2000 = 0.1 hours (6 minutes) or less

In comparison, if the same filter was filled instead with matting or plastic, there would be hardly any displacement and the filter will probably still hold in excess of 450 gallons, giving a retention time over double that of gravel. So a filter with a dense, low-void medium, such as gravel, will need to be substantially larger than one based on light-weight media, in order to achieve the same retention time, which explains why koi filters were traditionally so large.

Turnover - The quicker the better?

Just when everything starts to make sense, along comes a complication. While a longer filter retention time will produce better water quality we also have to consider **pond turnover times**. Why? Because polluted water is produced in the pond and, if there was a slow turnover at the filter, it would take longer for pond water to get processed by the filter.

To make sense of **pond turnover rates** it is helpful to return to the original analogy of koi being sewage-making machines: expensive food in one end and sewage out the other. Our seemingly impossible aim should be to remove this pollution as fast as it is produced. If we can manage that then we would have perfect water conditions most of the time.

When we are considering pollution the primary concern is not so much the volume of water, but rather the number of fish and the amount of food we feed to them - because this is what determines both the amount of metabolic ammonia and the quantity and quality of solid waste. There are several ways to calculate ammonia production in a koi pond. A rough and ready estimate can be made based on the amount of food fed each day.

How much Ammonia from that much Food?

Each kilogram (2.2 pounds) of fish food will result, on average, in 37 grams of ammonia being produced, together with copious feces. And there is other organic waste, such as that from decomposing algae and microorganisms. The important point is that as the stocking, and thereby feeding level, is increased the water will have to be treated at an ever quicker rate if water quality is to be maintained.

If, for instance, we had a pond of 4,500 gallons and the fish were fed 200 grams (7 ounces) of food per day, this would produce approximately 7.5 grams (7,500mg) of ammonia per day, an average of say 300 mg per hour. (In reality the ammonia level would fluctuate throughout the day, being highest shortly after feeding).

1kg food = 37g ammonia
1000g / 200g fed = 5
37 / 5 = 7.4g = 7400mg / 24hrs = 308mg per hour.

At this feeding rate, if no ammonia was removed, at the end of a day the ammonia content of the water would be 24hrs x 300 mg ammonia = 7,200 mg in 4,500 gallons of pond water, giving an ammonia concentration of 1.6 mg/gallon or 0.37 mg/litre, which is too high.

Conversely, if it was possible to remove the ammonia at the same rate as it is produced - namely, 300 mg per hour - the steady state ammonia level would be **zero**. Assuming we have a perfectly sized filter, then to remove ammonia this quickly we would have to pass the entire contents of the pond through the filter every hour, giving a flow-rate of 4,500 gallons/hour, otherwise there will always be some residual ammonia present.

Deep breath!

If, instead of a flow-rate of 4,500 gallons/hour, we had a flow rate of the pond volume every two hours - or half the pond volume every hour (same thing), an oversimplified calculation would give:

300 mg ammonia / 4,500 gallons (pond volume) x 2,250 (flow rate gallons/hour) = 150 mg ammonia removed per hour, leaving 150mg in the pond, or a steady state of >0.01 mg / litre. (This makes the simplifying assumption that there is no nitrification occurring in the pond.)

What is an Adequate Flow-rate?

So what is an adequate flowrate? As explained, it depends on the feeding rate.

The most commonly quoted advice is: turn over the volume of the pond between 8 and 12 times a day. Otherwise expressed as between one-third and one-half every hour.

Filter Size

Taking retention times and flow rates into consideration, when it comes to choosing the right filter size, there are two important but conflicting factors:

- the right filter retention time, which ensures all the required biological activity occurs,
- brisk water flow to prevent a high pond ammonia level.

If we decide that a flow-rate of say 2,250 gallons per hour and a filter retention time of 10 minutes are required then the volume of water in contact with the filter media at any time will need to be;

2,250 gal / 60 (minutes) x 10 (minutes retention time) = 375 gallons or 50ft3

This means that the filter should be able to hold 50 cubic feet of water after it is filled with media. This is in addition to settlement and spaces below the media trays. The required size of filter will then depend on the media used. Using a high-void medium, such as matting or plastic, we would need a little over 50 ft.3 of media to compensate for the small amount of water displacement, whereas, with a solid medium, we might need at least double the size to ensure the same volume of water in contact with the media after displacement.

Let the Water Flow

When initially designing the filter you have to apply some theory, as was just done in the previous sections. While the quoted factors provide a guide, you cannot be quite sure how accurately the pump really performs as compared to its intended statistics due to a variety of factors;

- pump rating,
- head of water it has to push from pond to filter, top outlet, or water feature,
- natural flow resistance in the piping and the pre-filter and bio-filter, UVC unit, etc.
- increased resistance over time due to solids building up if using a pressurised filter unit

After you have built your filter system, its simply a matter of timing how long it takes for the water to flow when filled up from empty.

For this experiment you should consider what constitutes the filter, and from which points to time it. For example the main priority is the bio-filter itself. Turn off the pump, then empty the bio-filter section by whatever means (drains, valves, unclip piping, etc), do them up again, and then turn on and time it.

In my case I consider the complete system to be from the inlet of my pressurised Bio-Force pre-filter, then into the bio-filter, and then on into the terracotta urn at the top of the waterfall because I also have some filter media in there too. So while my actual bio-filter unit is quite small, and the theoretical retention time calculated may at first sight seem too small to allow sufficient bacterial activity (the water goes through too fast), when the 'big picture' is taken into account and the effects of the pre-filter and urn are also considered, and you time it for real, then the calculated retention time can be extended by a certain factor. What do I mean by this?

Well when the water finally pours out of the urn, do you think the filtering stops there? No, of course not! As I have a waterfall, with plenty of algae formed on it, followed by a stream, then a bog area with various plants, then I can probably include these in the retention time as well because they will also have a residual beneficial action.

So I could consider the retention time to be from when I first turn the pump on, until the water starts to flow back into my pond at the end of the stream. Even then there will be natural bacterial activity on the pond walls. Another addition is that even though we have just timed the direct water flow effectively from point A to point B, there will be eddies and slower points where some of the water is held back by the filter media, plants and so forth. So the real retention time is likely to be greater than the mathematical model.

In larger filtration systems the maths is likely to be more accurate, but we know that even in small garden ponds with few fish, and without filtration that the water can be nice and clear just on the basis of balanced natural processes.

Summing Up

Ideally, what we want is a fairly brisk flow-rate, turning over the pond volume every 1 to 3 hours (depending on feeding and stocking rate) but at the same time a slow, almost imperceptible flow through the filter, allowing sufficient time for the various important biological processes to occur. Water passing through the filter should be in contact with the filter media, and therefore the biofilm, for at least ten minutes, possible longer.

There are enormous benefits to be gained by a fast turnover rate. More air/oxygen will be dissolved into the water. The solids suspended in the water will be removed more quickly resulting in a clear pond, and the fish impurities (ammonia) that are dissolved in the water will also be removed faster. Your fish will be more happy and healthy. Your water will sparkle. The colours on your fish will, generally speaking, be better.

As you increase the turnover rate the ambient level of ammonia decreases and at around a full pond turnover rate every two hours through the filter, or filters, the ammonia levels should be below what can be registered on a test kit.

As a rule of thumb a flow rate of between 60 - 80 litres (15 - 21 gallons) every minute per square meter (10 square feet) of chamber surface area will slow the water down sufficiently to give 100% conversion of ammonia in a single pass through the filter chamber but still maintain the high pond turn over rate you are trying to achieve. A slow flow rate such as this will also encourage settlement of solids.

As a working example: Pond volume about 5000 gallons. Pump needed to turn the water over in under two hours = about 44 gallons per minute flow rate (unrestricted). Filter chamber surface area to cope with a flow rate of 44 gallons per minute = about 22 - 29 sq. ft. (15 - 21 gallons per minute per 10 square ft).

You don't have to rip out your existing filter if it does not fall within these parameters - if your fish are alive and well and growing you are doing something right. You can also make some clever 'adjustments' or minor modifications to your existing filters to achieve these parameters.

So for example if you're building a 3000 gallon pond, you will need a main filter pump capable of delivering at the very least 1000 gallons per hour (3000 divided by 3). However, pump ratings are all given at zero head, the height between the pond surface and the point that water is returned to the pond. The more the head, the less the flow rate, as more power is required to push the water 'up hill'. All pump manufacturers calculate the maximum recommended head for their pumps and provide a chart giving the final flow rate at a certain height of head pressure.

Sunshine

Another consideration when calculating the volume of water that a bio-filter must manage is as follows:-

Add 25% to your basic volume if your pond is in full sunshine - because the water will warm up quicker, and algae will grow faster. Add another 25% if your pond is less than 75cm (2' 6") deep - because a high percentage of the water in the pond is exposed to the full power of the sun and algae will grow faster. Then add between 15-35% to your pond depending on where you live, if the pond is in the UK, it is going to be cooler and less sunny than if the pond is located in a country near the equator. If it is hotter and sunnier then algae and fish will grow faster.

This then gives us an effective pond volume, which is the amount of water we need to filter. Again the entire effective volume of the pond has to pass through it approximately once every two hours.

Lets say the pond is in full sun, in South Africa. It is 0.9m x 0.9m x 0.9m (3' x 3' x 3') so would have an actual pond volume of approx. 730 litres (160 gallons). In this example we would add 25% for the pond being in full sunshine and 35% for the lovely African climate giving a total addition of 60%. Therefore, we must filter the ponds effective volume (730 x 60%=1168) of 1168 litres (257 gallons), and any pump used should have a flow rate of at least 584 litres per hour (128 gallons per hour).

So we would filter the pond as though it had 1168 litres of water in it, and any pump we use should have a flow rate of 584 litres per hour.

My Calculations

Although my needs are very small-scale, perhaps even not worth worrying about from the point of view of ammonia production, I thought it would be an interesting lesson to perform the calculations for my setup.

First of all I need to estimate the amount of ammonia my fish produce in a day. This is likely to be quite low because I have a small pond, with only 14 small to medium fish (largest ghost koi is about 12 inches).

Feeding the Fishes

I use Tetrapond Floating Food Pellets in a 1150g tub. I wasn't sure what weight of food I was giving them each day. I only thought of it as a couple of medium size handfuls in the morning and again in the evening, possibly a little more at weekends when the grand-children like to see and feed them. So to get an accurate idea I got the tub of food, some weighing scales and found that it took 7 full handfuls (as much as I could grab) to give 100g of food. This gives roughly 14g per handful, maybe 10g for a small fistful, more like what I actually pick up when feeding them.

So I feed them about 4 medium handfuls per day, which equates to between 40g and 60g per day. This is nothing like the figures we were using earlier on this page, which at 200g were probably more the norm for real koi-keepers. In fact when I measured out just 100g of the pellets I was surprised at what a large bowlful it was. As an aside if I feed an average of 50g each day, the tub at 1150g therefore should last me 23 days. In fact the tub lasts much longer than this (more like 2 months), and I think its because I am more of a sucker when feeding the fish, than when my wife feeds them!

Now lets calculate the daily ammonia:-
1kg food results in about 37g ammonia excreted by the fish
1000g / 60g maximum fed each day = 16.6
37g / 16.6 = 2.228g = 2228mg / 24hrs = approx. 93mg per hour.

As stated earlier each square meter of biologically active surface can metabolize nearly one gram of ammonia per day. My fish produce > 2g each day (2228mg). Lets say 3g to be safe because they probably forage and eat other food in the pond, although it will be of very low protein content. So I need an SSA of at least 3 square metres. I'm using scouring pads as the media with a ratio of 300:1, or 300m2 for each cube metre of media. Imagine a box 1m x 1m x 1m, its quite big. But now imagine a big flat square 300m long and wide (think 3 football pitches long on each side), now mentally fold up that area and pack it into that box. Thats quite a remarkable area to fit into the box!

So 1 cubed metre / 300 = 0.0033m3 (or 3300cm3). That is 3300cm3 required per m2 per gram of ammonia. We reckoned on 3g ammonia, 3 x 0.0033m3 = 0.01m3 (10,000cm3) of filter media. The square root of 10,000cm = 21.544cm, so roughly a 22cm length x 22cm width x 22cm height cube would be a sufficient amount of media to handle the ammonia. Scouring pads don't come as one big lump though, so they would actually need a slightly larger container!

Turnover

My pond contains about 400 gallons, and my pump is rated at 616gallons/hour at 1m head, although its maximum flow rate is quoted as 4000litres/hour (880gallons/hour). I will add 25% for the pond being in full sunlight, and 15% because I am in the UK, so giving 40% and resulting in 560 gallons effective volume. Therefore I need a flow rate of only 280 gallons per hour (half the pond volume), or about 4.6 gallons per minute for recommended pond volume turnover.

My waterfall is at about 1m above pond surface level, so in fact my pump at 616gph / 560 = 1.1. So every hour the whole pond water would be recycled one and a bit times, or about 21 times in a day. Thats a very fast turnover considering the recommended is 8-12 times a day. In fact it will be less than that because my Cascade pump also has a bell-effect water fountain, so some of the water just cycles in the immediate vicinity of the pump within the pond rather than going to the filters. Perhaps I can use my fountain to help reduce the power and flow of water that is directed to the filters so as to increase the retention time in the filter, but I have a feeling that my stream would then be little more than a trickle. Catch 22!

Retention Time

Hmmm. I have a feeling this is going to be ridiculously small. Suppose the bio-filter were based on a 22cm cube (the figure calculated for SSA earlier for the ammonia was 10,000cm3). This would hold about 2 gallons of water. But the pump at 616gph would push the water through in about 12 seconds!! Thats a far cry from recommended RT of 10 minutes. Even if I reduced the pump flow to my desired 280gph, that still only gives a 25 second RT.

So lets work it out the other way, to figure what size the bio-filter should be to obtain 10 mins RT:-
280 gal flow-rate / 60 (minutes) x 10 (minutes retention time) = 46 gallons or 7ft3 (about a 59x59x59cm cube).

What does this mean? We seem to have a contradiction in that the amount of ammonia my fish produce suggests I need a filter capable of holding only 2 gallons, and yet to hold the water for 10 minutes, I need to increase its size to 46 gallons!

When I looked at the size of commercially produced bio-filter units rated for my size of pond I thought that as long as I build something of similar size I can't go too far wrong. What surprises me however is that the theoretical calculations as described on this page, when applied to the dimensions of such commercial filter units, indicate that the small-scale units are far too small to achieve anything near a 10 minute retention time! Also when you consider that these units usually have half their volume as pre-filter, and the other half as bio-filter, and often using a plastic filter media with a lower SSA ratio of say 180:1, then I am skeptical of them achieving any benefical biological filtration because the water passes through far too quicky.

Surely they can't be too far wrong though? I can surmise in my situation that ultimately the filters main function is going to be creating clear water, rather than reducing ammonia.

The Real Thing

When it comes to the actual practicalities, and the size of container (big flower pot) I have chosen it actually works out more like this:

The pot is a cylinder of average diameter 38cm (it narrows slightly from top to bottom, so I take the measurement at the middle). It has a filter media depth of about 32cm (the pot is actually taller/deeper but the media itself is 32cm deep). To calculate the volume we use Pi x radius x radius x depth, or 3.1415927 x 19 x 19 x 32 = 36291cm3 = 8gallons. A flow rate of 616gph would have a retention time of 46 seconds, and if reduced to 280gph would be 1 min and 42 seconds.

As mentioned earlier, after building the filter system, time how long it takes for the water to flow when filled up from empty. I did a test and timed my completed system: pre-filter, bio-filter, water-feature urn, waterfall and stream.

It takes 4 and a half minutes before the water spills back into the pond again, which is nearer the goal of 10 minutes retention time, and I believe is probably adequate for a pond of my size.

Next stage is to build it!

HOW TO BUILD A DIY BIO-FILTER FOR YOUR POND

Right. This is where I show you how I built my own bio-filter based upon a "Skippy" filter. This section covers the following topics:-

Let's Build It!

You should consider as we go that this was how I built a bio-filter for <u>my</u> pond. Assuming you are attempting a DIY approach you will obviously need to adapt it to your situation.

I already had a small filter (Hozelock Cyprio Bio-Force 2200 UVC), and a pump (Hozelock Cyprio Cascade 4000).

I also wanted the water coming out of the filters to go into the back of the terracotta urn (via pipes going into holes I drilled in the back of the clay urn), spill out of the mouth of the urn, down the waterfall and the stream.

So consider your own needs, and plan accordingly. I find this works for my size of pond (400 gallons), but you may need to upsize!

The Big Search

A key factor in my minds eye was to use a big plastic flower pot. It should look better than a big black tank - not so obtrusive, would be easy to drill holes in, and a cylinder contains more volume than a square or rectangular tank of similar size. And as mentioned previously water swirls inside it more naturally. So I visited a couple of garden centres to see what I could find.

Hmm. Nice big pot.....

....but the patterning would be awkward to drill through and create a waterproof seal.

An even bigger pot. More like the size I want......

...and the patterning has enough space around to allow drilling and the water outlets to sit flush.

Another pot, but smaller, and it had extrusions with holes in the bottom making it useless to hold water in.

Excellent, I have also found a plastic sieve which fitted perfectly in the bottom of my chosen pot which the filter media would sit on top of, thereby creating a gap for the water vortex underneath.

Parts

Basically I now simply needed a variety of pipe fittings, clips and hoses to work with:-

- Big pot 47cm diameter across the top (£20)
- 25mm Flexible hose (in fact the black hose shown here was very stiff, and didn't get used in the end, £6 wasted! I got some other more flexible hose later on 2m of 40mm hose to exit the filter, and 3m of 25mm to enter the bio-filter)
- Plastic sieve (£2.50)
- 40mm U-Bend piping kit (all necessary rubber seals, and fittings included, £5)

- 40mm Shower drain unit (one of the more expensive items £10)
- 25mm black double-ended hose connector (£4, I got this to join existing piping at my Bio-Force UVC filter when I excluded it from the loop. In fact I put the Bio-Force back in as a solids pre-filter, so this connector was not used after all)
- 3 x 22mm pipe right-angle bends, push fit (99p each)
- 2 x 22mm pipe T-pieces, push fit (99p each)
- 1 x 22mm pipe tank inlet, straight-through (£1.25)
- 2 x 22mm pipe tank overflow, right-angle bends (£1.25 each) NB. one of these was later replaced with a 40mm tank outlet, see below.
- 4 x 18-30mm metal screw-adjust "Jubilee" hose clips (50p each pack)
- 22mm plastic water pipe, 2m length (£1.50)
- Also (not pictured),
  - A pack of Pond Bacteria culture to help start maturing filter,
  - a 40mm tank overflow outlet (I used this to replace one of the 22mm ones later on to ensure good exit flow from the bio-filter back to the pond)
  - Fernox LS-X jointing compound and leak sealer glue (dries rubbery, acetic acid (vinegar) base which cures on contact with water)

Starting Work....

The shower-drain unit by coincidence matched exactly the size of the recess in the bottom of the pot.....

Using a drill of the right size to match the shower-unit, drill through the base.

Pilot hole first....

...then main hole.

A perfect fit. See notes about sealing this with plumbers jointing compound later on. Extremely important.
See that 6 spoked plug hole centre? You can take it out, so I removed it to give better drainage otherwise it blocks up all the time.

Inlet & Overflows

Consider the angles of where you want your pipework to enter and exit the bio-filter, i.e. where are your pump, pre-filter, and returns back to the pond located? This should dictate the orientation of your bio-filter tank, how the pipes come to it, and where you intend to put buckets/watering-cans when emptying the filter, or even where the waste water will go to if you're just emptying straight onto the ground. Plan and mark out where you want the inlets and outlets to go. In my case I found that this was partly dictated by the raised flower pattern decoration on the sides of the big pot, because I had to drill in between on the flat parts.

Now drill and fit the inlet and overflows. I would recommend not doing things up too tight or sealing them during the experimental stage to allow for adjustments to be made. I created 2 overflows because I knew that my pump would force more water into the tank under pressure than would be allowed out under gravity. In fact, much later on **I replaced one of the 22mm outlets with a much larger bore 40mm outlet and flexible hose**, which works much better at letting the water out. I was concerned about these narrow 22mm pipes becoming blocked and causing the bio-filter to overflow, so losing all the water from the pond with potentially disastrous consequences!!!

Drill to accomodate the 22mm pipe fittings for the one inlet and the two overflows. Notice how I had to fit it between the raised decorative pattern to ensure a flush fit.

I experimented with angling the pipe of the overflows to determine the water-level inside the filter. Later, after final assembly, I took them all out again, applied a generous helping of Fernox jointing compound to the inside and outside faces, and the flexible hoses before re-fitting.

This gave a totally watertight fit with no leaks!

This is the 40mm outlet and piping which I used later on....
(notice the jointing compound to seal the join).
This pipe feeds off into a large hole carefully drilled into the back of the terracotta urn, which sits at the top of the waterfall.

This larger 40mm outlet has much better capacity
to let the water flow out.

Main Flush Drain

Next task was to fit the shower-drain unit, and measure and cut the pipework to create my main drain outlet. My idea was to have the pipe clipped against the side of the tank. I lubricated the rubber seals for the pipework with vaseline, not only to provide a good watertight seal, but also to allow the whole pipework to be unclipped, and rotated easily to allow emptying of the filter. I figured that pipe of this bore would allow the water to exit rapidly, so dragging any muck out quickly. In practice this works a treat, and allows a very quick cleanout every couple of days, taking no longer than a minute, dumping into a watering can, and the pump still running. Easy maintenance!

The length of the pipe allows me to lower it over a watering-can which can then be used to water plants around the garden, or to fill up a bucket for cleaning of the pre-filter foam or the bio-filter media. And also because the top of the pipe is open, I can put Bacteria Culture into the top, and literally "inject" the bacteria right into the heart of the filter, by pouring pond water in to the pipe. All will become clear!

Another thing to mention is that the shower drain has a 6-spoke plughole centre (see earlier picture). It is possible to remove this, and its shower trap shaft. This would normally form the trap for any hair and muck which normally goes down a plug hole, but I found that this just got blocked up with algae/blanket-weed so I removed it altogether. This improves draining the bio-filter quite substantially, and also allows a clearer passageway for sediment to drift down into the main body of the trap, ready to be flushed out.

Note that due to the protrusion of the shower-drain unit and pipework at the base of the tank it is necessary to have a sturdy platform to straddle each side of it, and support the weight of the tank and water. This is achieved very nicely by two house bricks sat on top of a level paving slab, which give a solid sturdy base. When the tank is filled with water it is very heavy!

The main drain assembled. The point of rotation is on the axis where the pipe goes into the shower-drain unit. I unclip the pipe from the side of the tank, and pivot it left and down. The water will then flow out of the main riser pipe.

The tank is now filled with water to see whats leaking!

Hmm. Plenty! A leak is not good here. Again while I was still constructing the whole thing I didn't worry too much about sealing, but once I had the design and any tweaking done, I used some Fernox plumbers jointing compound. This is wierd stuff which is clear, smells of vinegar (because it uses acetic acid to help the curing process), and sets on contact with water. It doesn't seem to hurt your skin so even though its not pleasant I used my fingers to spread it over the surfaces - I used plenty - rather be sure than sorry. Keep it away from your eyes though!

When set it is rubbery and pliable, and creates a very good seal. I paid a lot of attention to making sure the shower-drain unit, and the main drain pipework were very tight and well sealed, either with Fernox where I didn't want it moving, or with vaseline where I intend the whole pipe structure to rotate when emptying the filter. Note also that I used the Fernox on the inside where the nut & bolt are holding the pipe clip to the tank, to make it both watertight, and help prevent corrosion.

There is one thing I am wondering about with my design. Whether there is a risk of the bottom drain/u-bend freezing in winter, and expanding so causing leakage, or at worst total flood-out of the pond. Hmmmm!? Perhaps there won't be a need to run the bio-filter in winter for my size of pond and fish? Or perhaps the constant flow of water will keep it from freezing? This is something I will have to keep a cautious eye on.

Update: I had no problems this winter just gone, even with the top of the pond actually freezing over.

Obviously the water level in the tank also rises in the pipe on the outside, so the length of the rising pipe must be sufficient to always be above the maximum expected level of water inside the tank, otherwise it would overflow from the top of the up-pipe! Not what you want!

At this stage I found that there was some natural give and droop in the pipework due to the rubber seals, and the added weight of the water in the pipe, which the plastic clip holding the pipe against the tank could not support. To cure this I added a couple of screws to help hold the pipe up on the topside of the clip. See below. At the time I kicked myself for not cutting the pipe longer, but in practice there is just sufficient height for it not to overflow. The water goes out of the proper outlets as intended.

Settlement Chamber Vortex Swirler

Note that this build section was modified later on when I added the venturi. Please read the whole project contruction process before starting to cut any pipework! (Unless you don't want to build the venturi).

My theory for the settlement chamber was based on the idea proposed by the Skippy Filter, where the water is fed to the bottom of the filter under pressure and out of two pipes in opposing directions to create a circular swirling vortex motion. The idea being that:-

- its better to keep muck out of the bio-filter, so this settlement chamber hopefully catches anything let through by the pre-filter
- the water is distributed evenly around the settlement chamber before moving upward through the garden sieve and the filter media
- a whirlpool or vortex action causes muck and sediment to move to the centre and settle downward into the drain unit ready for expulsion when the filter is emptied

This is the basic layout - a down pipe goes into a T-piece, then outward to the right-angle bends to create a clockwise motion of the water.

Here is the swirler measured, cut and assembled. Note the slight downward angle at each end to help move sediment to the floor of the chamber.

Now get the sieve. Fairly ordinary. 36cm diameter.

With the lucky combination of this size of sieve and the diameter of the main tank, when the sieve is placed in the tank as far down as it will go and rests on the sides, there is still about a 2 inch gap between the bottom of the sieve and the floor of the tank for the vortex.

Cut out a segment from the centre of the sieve. This segment, I found out once again by chance, was a very snug fit for 22mm pipe to pass through. How lucky am I?

And now the swirler can be put in place through the sieve. The T-piece fits nicely against the bottom of the sieve without going through the cut-out segment.

Note in the picture below that the top of the swirler is against the bottom of the sieve, with about a one and half-inch gap from its underside to the bottom of the tank.

Next put the swirler/sieve assembly into the tank and measure the rising pipe length to the pump/pre-filter flow inlet flange.

After cutting the pipe, put a right-angle bend on the top.....

Then measure and cut the pipe for the feed from inlet to the down-pipe, and fit in place......

Some more testing to see how it all works, check water levels, overflows, and swirler action.

So far so good! Although I'm a bit dubious about the very stiff black pipe I've got. Think I need to get something more flexible.

During testing and filling, I discovered that air trapped under the top lip of the sieve was sufficient to cause it to float upward, so I drilled several holes around its circumference. Not too many because I want the majority of the water to be channelled up mainly through the bottom of the sieve, not through the holes at the outer side of the sieve.

Final Assembly

Finally all that is required is to assemble everything, put the filter media in, start the pump and check for leaks.

Again I did a test run before securing everything, because once in place I found that there were several small leaks around the jubilee clips used to connect the hoses to the inlets and outlets. A good daub of plumbers glue fixed the leaks. Also note in this photo that I have fitted better flexible hosing rather than the very stiff hose I got initially.

Once you are happy with everything, put the filter media in.

The Big Green Scrub-Up! (Filter Media)

Skippy's site recommends industrial size green nylon scrubbing pads for the filter media. Lots of people seem to use and recommend this stuff. Despite its rather innocent normal purpose, it has a high surface to volume ratio of 300:1 making it a very good surface for bacteria to colonise.

It was quite hard to find a supplier of the big thick pads. I did not use the circular pads used on floor cleaning machines. They were quite expensive, and I needed quite a lot. A friend offered me a whole load of these free, but they had been used and though he cleans them afterwards I was concerned that they would contain floor cleaners and traces of dirt that would either prevent the bacteria growing, or worse could poison my fish!

It amazed me how much people charge for this stuff! Normally housewives buy this from their supermarket in a little pack of 5 for their housework and it lasts them a few months, so they don't mind paying a couple of quid. Skippys supply it in bulk at a very reasonable price, but they are based in the USA.

After much searching I found a reputable Internet company in Scotland called **Scobies Direct** who are suppliers to the butchers trade. Butchers have to clean their work surfaces very regularly, so Scobies supply these large size scrubbers in bulk. I ordered 1 box of 120 pads which was plenty for the task (and still I had about 50 pads leftover). It arrived 2 days later. These scouring pads are 230 x 150mm x 8mm, designed for industrial use and are suitable for all cleaning applications - and ponds! Now if they are suitable for cleaning surfaces used for preparing meat on, then I think they will be alright for my fish! They probably aren't quite as thick as the ones supplied by Skippy's (which I think are more like 15mm), but they seem to be perfectly adequate for the job and are slightly thicker than the usual dishwashing green scouring pads.

At Scobies just go to the Sundries, Disposables section where you will find them, or click this link:-
http://www.scobiesdirect.com/ItemInfo.asp?PageNo=1&ItemNo=DP40003&sMethod=ProdCat&CatName=&ProdCat=50027

At the time they cost £14.95 for the box, the total order was about £23 after VAT and UK post & packing.

Update: Recently I was told that Scobies are having stocking issues with these pads. I am trying to find out more from Scobies currently, but in the meantime I have located an alternative stockist who charges a bit more. They are **Akro Services** and you can find their **Green Scourer Scrubbies Pads** (product F959 currently at £2.75 box of 10) by clicking here: http://www.akroservices.co.uk/products.php?cat=165

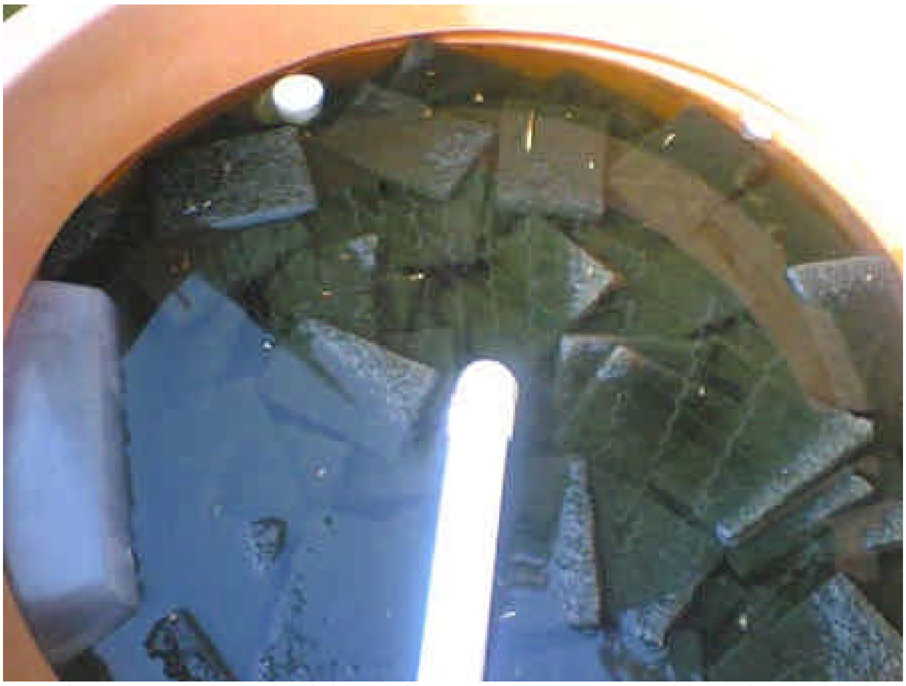
Another supplier that I have been told about is **Ace Janitorial Supplies Ltd** in Sheffield, UK. (Tel: Paul Cullumbine on 0114 244 4474 or 0114 244 5035), Email: info@acejanitorial.co.uk, Web: www.acejanitorial.co.uk. They supply 9x6 inch contract scouring pads in **boxes of 50** for £6.60 inc. VAT per box.

A friend of mine who has a much larger pond, built two filters using two 80litre bins from B&Q and based on my design. They feed one into the other for his **3000 gallon pond**. He bought 10 boxes initially (500 pads) but later found that 6 boxes were sufficient for his two 80 litre bins.

To load the filter, I simply set the water running through the tank, so I knew the top level to fill up to with the filter media. then simply set about cutting up the pads. They are good size pads, so most I cut into quarter size, while some I only cut in half. As they went in, I gently pushed them down to soak them, and get them to fill all the gaps nicely.

The idea with using these is that they create natural voids between them which the water can track between, so the filter won't become blocked by any solids which get through from the pre-filter. The intention of the media is to slow, not block, the passage of water through so as to maximise the time the water is in contact with the bacteria who make their home on each pad.

Once finished there was still a good flow of water through, which after exiting the filter still gave a nice gush of water from the terracotta urn, and down my stream.



I also cut a plastic carton to fit around the main overflow to prevent the pads from going over it and blocking it up.
It turned out that this wasn't really necessary, because once wet, the pads pretty much stay where they are put.

Friendly Bacteria

One thing I like about the main drain is that it can also act as an "inlet" to the filter.

To get the filter started I poured the contents of a packet of bacteria culture into the top of the main drain and then poured enough pond water (NOT tap water) into the pipe to flush the bacteria powder through into the heart of the filter (probably a gallon of water).

This was done while the pump was running and will help jump-start the new bacteria forming in the filter, and the pond.

Every Little Bit Helps

The box of 120 filter media I got from Scobies Direct had plenty of pads to fill the filter, and then some. I figured that I could extend the bacteria colony beyond the actual bio-filter.

Anaerobic bacteria live anywhere in the pond, in the silt, on stones, on the sides, on plant roots. The bio-filter is simply their main home.

So why not give them additional living quarters in the terracotta urn at the head of the waterfall?

So I simply cut up and added a stack of the scouring pads into the urn as well. This should mean there are even more bacteria available to purify the water.

Additional Tweaks

This photo shows the Hozelock Cyprio Bio-Force 2200+UVC filter hiding under a curry-plant. Click here for the Hozelock Cyprio site. I mentioned on the Introduction page that I made the mistake of thinking a pre-filter wasn't necessary with a Skippy filter, and so for a couple of weeks I totally bypassed the Bio-Force filter (luckily I didn't remove it since I thought better not until I had tried things out).

Well after reading some more, like I said I learnt of other people saying their Skippy's were becoming very glooped up with cruddy slimy waste, and more knowledgable people saying its best to use a pre-filter to cut out as much of that solid fishy waste as possible. So I reconnected the Bio-Force back into place, and now when I do a cleaning dump on the main bio-filter, there is certainly not as much nasty looking gloop.

I just wish there was an easier way of cleaning the Bio-Force. I still need to clean it out every 2 or 3 days because it gradually gets blocked up and the water slows to a trickle. While I'm quite used to doing it, it is a bit of a pain bending over, unclipping the top, removing the coarse and fine foam rings, cleaning them out thoroughly, and then putting them back, while also being careful to get the rubber sealing ring back in place without trapping it, or it dropping into the casing and having to open it up and retrieve it again!

The one consolation is that I know it is catching all that muck, and believe me, there is plenty.

Update for 2005

Do I still use a pre-filter / mechanical filter?

Before I built my Skippy-style bio-filter initially I was using the Hozelock Bio-Force UVC filter. As you've read you'll realise that I was totally fed up with cleaning this out, especially in the summer, every 2 days because the water would absolutely **STOP DEAD**. It would get so blocked up with large and fine particles in the foam sponge that no water could get through at all.

Basically the Bio-Force UVC filter was not man enough for my pond, even though its a small pond! The ultra-violet light certainly seemed more of a gimmick than anything because it never helped my green-water problems, and the foam filters in the unit just clogged up too quickly. **Bacteria NEVER got a chance to breed or work in this manufactured filter**. It was just too small and I was cleaning it out too regularly.

Cleaning the Hozelock filter out was time-consuming, messy, cold and fiddly. Turn off the pump, unclip all the clips on the top, lift up the top carefully making sure not to bend the pipes too much (which invariably created leaks), squeeze out the foam filters (cold, wet, not fun), then put it all back together, making sure the rubber seal was seated correctly (which one time when we went on holiday and my neighbour was left in charge, he didn't do properly and the pond nearly emptied dry!!), then re-clip the clips (which are quite tough to snap back into place, and one clip broke off).

Anyway, when I had first completed my DIY bio-filter, I decided (like you are probably also wondering) to keep the Bio-force UVC filter plumbed in just before my Skippy bio-filter. So this was pre-filtering the muck before the bio-filter, which meant I STILL had to clean out the pre-filter every couple of days!

Now on the Skippy web site, they say that they don't use a pre-filter as such. I emailed them about this, and they said that the plastic or wire cage at the pump in the pond is usually sufficient.

Well time went by, and this winter just gone, one day when I was cleaning the Bio-Force filter, the plastic feed pipe leading into it "gave up". It was brittle in the winter cold, and had been bent too many times by me lifting the lid of the filter off.

So I had no choice! The pipe was now too short to lead into the Bio-Force unit, and I was too lazy to repair it properly (I would need to dig up a considerable part of the the rockery to get to the pipe, refit a new one, and re-plumb it in). So I went for a quick fix and cut and re-joined the pipe directly to the Skippy, so omitting the Bio-Force UVC filter altogether.

Since then (several months) my DIY bio-filter has been operating **without** a mechanical filter other than the plastic cage that surrounds the pump in the main pond (and which you might note from above, I had drilled a whole load of extra holes in the cage to allow water and muck to pass through more easily).

IMPORTANT: If you read my Design section about the theory of the bio-filter, I explain that you get two types of bacteria aerobic and anaerobic. The aerobic bacteria are the good ones that really help the digestive process of the bio-filter, just like a sewage farm. Anaerobic is what results in stagnant still water, and you do NOT want that kind. Anaerobic (bad) bacteria might be more likely to occur without a pre-filter because it might allow more fish poop to accumulate. Now sewage farms use huge pumps and mixers to pump air into the sewage before it goes into the filter beds. So I use the same principle by adding a homemade **Venturi** at the top of my bio-filter. It sucks air into the water, creating bubbles which mix, get passed down into the heart of the bio-filter, then bubble up and out. I believe that this really helps a lot. The waste solids can sink to the bottom for flushing out, and **anaerobic** bacteria doesn't get a chance to develop because 24 hours a day oxygen is being dissolved into the water and passed through the filter so encouraging just **aerobic** bacteria to develop.

So far this year it all seems fine. Yes I am getting some algae and blanket weed while the pond develops its biological cycle, but the water itself is clear as anything, even though it gets a good deal of sunshine. I shall have to wait until summer to see how well it all copes. But I am confident.

Also note that I have stuck by my word of not using any other kind of commercially available chemicals to treat the water. This is a totally natural system. The only thing I do is boost the bacteria by injecting some into the Skippy. Oh and make sure to use plenty of water plants too which help the balance and eat up extra nitrogen.

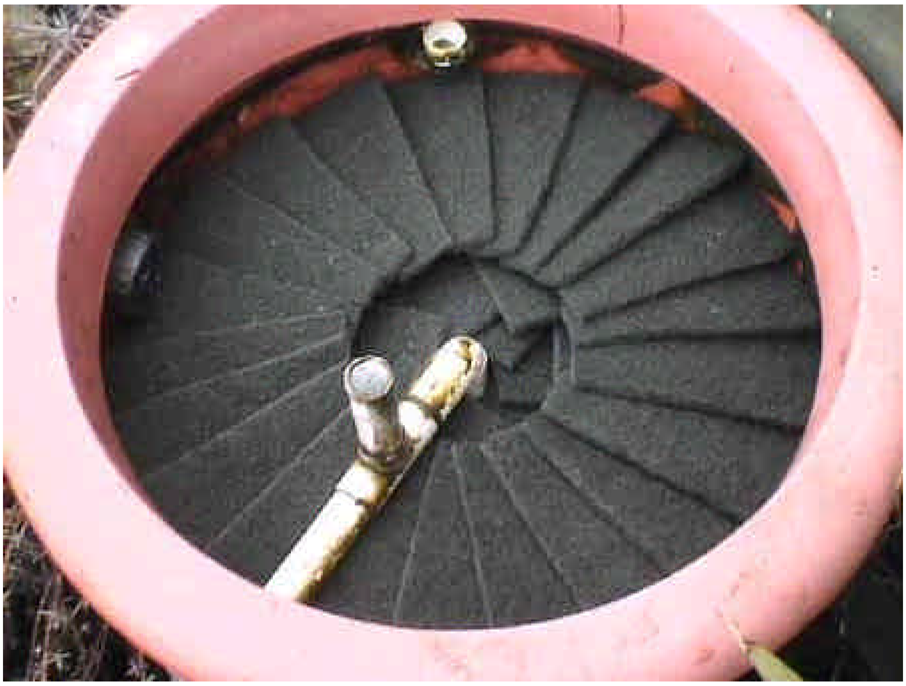
Re-Arranging the Filter Media

This year (2005) I have tried something different. At the start of the year I gave the bio-filter a total clean. This is ok because it was still the cold time of year when the bacteria are likely to be dead anyway. When I put the green scouring pads back into the filter I laid them carefully in a spiraling arrangement. Whereas previously I had just chucked all the pads in, this time my thinking is to close the gaps up, making its filtering process more efficient, and to also encourage a slow rotating motion of the water as it passes up through the filter pads. I made sure the direction of the rotation was also the same as that setup by the swirler pipes in the bottom of the bio-filter.

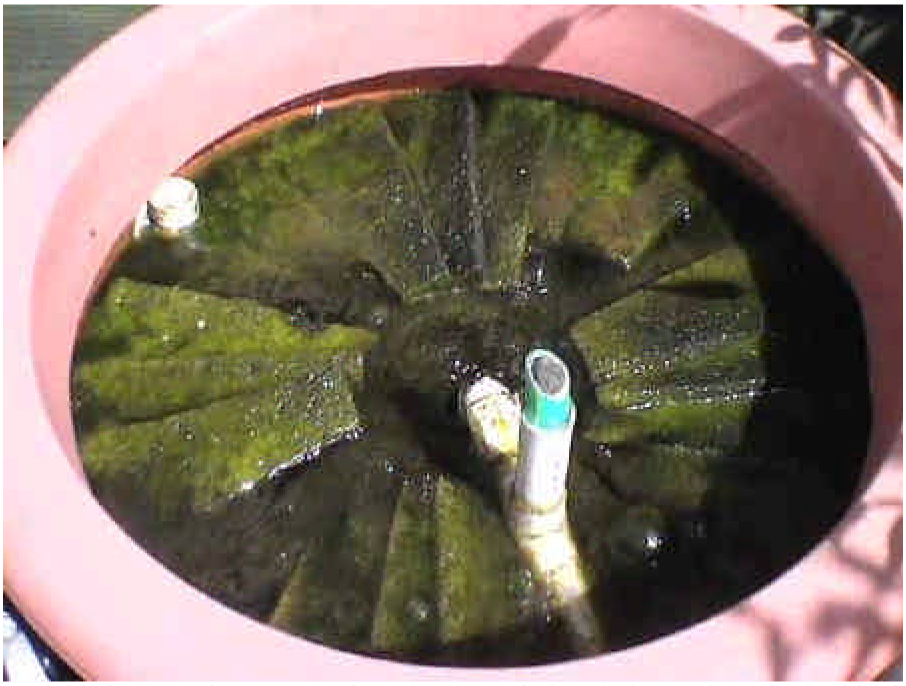

These are the old, rectangular scrubbies after cleaning, being laid in a spiralling, overlapping layout.


And similarly in the centre, always overlapping in the same direction.

Finally I cut diagonally shaped scrubbies for the last couple of layers at the top.



Here are the diagonal cut scrubbies in place, and all ready to go.


And this is after about 3 months. The bacteria has built up nicely in the bio-filter, and as you can see there is algae growing on the top where it is exposed to sunlight. I still haven't put plants in the top yet. I keep meaning to, so that the big bio-filter pot looks as if its just a plant pot, but I guess I just like fiddling with it too much. Also notice my new Zik-style venturi in the top which draws air down to aerate the water before it goes into the bio-filter. This extra air oxygenates the water so that the "good" bacteria can live and breed and do their stuff on all the waster matter in the bio-filter.

Pump Modding

A **big** mistake I made, and would strongly advise other newbies to pay attention to is to **make sure you buy an appropriately sized pump that is adequate not just for its immediate, but also future needs**.

I am on my second pump now, and am considering a third. The Hozelock Cyprio "**Cascade**" pumps are really intended for small fountains and waterfalls. Granted that is what I have, and to be fair it suited the purpose at the outset, but now I've crossed the threshold from requiring a pump with a fine filter cage, to needing one capable of pumping solids, i.e. something more like their **"Titan"** range of pumps.

So whats the difference?

Cascade vs. Titan

Well, the "Cascade" has a plastic casing around the pump impeller that prevents solids going up the tube to the fountain spray, because without this the fine holes of the fountain spray-head would block very quickly. The pic below shows the surround casing after removal from the pump motor (which enables it to be cleaned). As you can see the slots are reasonably fine, each one is about 2mm wide, by 15mm long. They are intended to keep out solids; fish waste, bits of leaves, algae, blanket weed, etc. Which they do! But it tends to clog up so much that eventually the flow of water is inhibited. Then you have to get it out of the water and clean it.

If your pond has a fair bit of muck, and the fish constantly stir it up, then the cage could block up within 3 or 4 days. Maybe if you are using it to power just a fountain spray head which does not require much pressure then it would last quite a while. However for my purpose, since I need a reasonable throughput of water, the reduction in pressure soon tells.

Due to the evolution of my pond, I now need to push those solid wastes out of the pond, and my Cascade blocks up too quickly. I was having to remove the actual Cascade pump unit from the pond every 3 or 4 days, let alone clean out the Bio-Force filter every couple of days!

So I studied diagrams of the Titan pumps, and looked at the spare impellers sold in my local garden centre and compared ones for the Cascade, with ones for the Titan. I identified the following differences:-

- The Titan has a larger cylindrical filter cage around the pump unit. This larger area will allow a more even continuous flow of water into the cage, even when covered with a layer of blanket weed.
- The Titan is advertised as being "eco-friendly" with a Wild Life Protection System (WPS). What this actually means is that there is a secondary cage at the base of the unit with sliding slots. When fully open these slots are about 10mm wide by 25mm high, but can be closed down to 2mm in spring to prevent small critters being sucked up to an untimely demise!
- The slots on the Titan are at the very base of the pump which therefore is able to draw muck directly from the floor of the pond.
- The impeller that actually does the pumping is identical for both the Cascade and the Titan, but for one thing. On the Cascade impeller there is a sort of cap, which presumably helps make the impeller more efficient because it "draws" the water better. On the Titan impeller this cap is missing, which means that larger solids won't get caught/trapped in the impeller device.

The Cascade 4000 impeller has a cap over the impellors vanes. Water is drawn in from the front (left-

The Titan 2000 and 3000 impeller is the same, but without the cap. Note the little lugs on the hand side of photo), and pushed out of the sides. It's not intended for solids like stones, snail shells, etc, which could get trapped inside the cap.

vanes which the cap would fit on if included. Ok, its green too: Green = Titan!

The Titan 5500 is however considerably larger and different.

Having spent the best part of £140 now on two pumps, the first rated at 2000litres/hour (440gallons/hour), and the second at 4000litres/hour (880gph), I now know I would have been far better obtaining a slightly higher rated Titan with solids handling capability (perhaps the 5500litres/hour model) right from the start. [I go into the power aspect a little more on the Venturi page].

My advice - <u>don't just go for power</u>. **Consider the additional function of the pump for your purposes**.

What do I do? I'm going to be a tight old cheapskate and modify my Cascade to emulate the Titan in "summer" mode.

Or in plain speaking terms, I am going to get out the cage from my old Cascade 2000 (its exactly the same size as the Cascade 4000), and butcher it by drilling quite a few extra 8mm holes all around the base so that it can draw in solids and more water from the bottom. This photo shows the bottom of the cage before and after drilling the holes. The drilled cage will be my Summer pump filter, and the original cage will be my Winter/Spring pump filter.

How effective was it? Well even the larger holes still block up over time, but I have effectively increased the amount of inlet space to feed into the pump. The length of time between cage cleans has now extended to about 2-4 weeks. That'll do for me at least until I can afford a new Titan 5500 (another £130!). And if something like a stone or snail shell gets trapped under the Cascade impeller cap, I will simply remove the cap as for a Titan impeller, and see if there is any reduction in power.

[Sub-note: Stuff did start getting stuck in the impellor cap, and because it was getting quite old and worn I removed it. The main wear on the impellor was due to a small bush which got lost during one of its routine cleanouts, which allowed the impellor cap to move too close to the impellor housing which it then hit against and started to crack the impellor cap. The damage was not as a result of stones or snails, they would just get stuck in the impellor and probably reduce its efficiency. I bet those snails got dizzy! Anyway there was only a slight reduction in the power after removing the cap.]

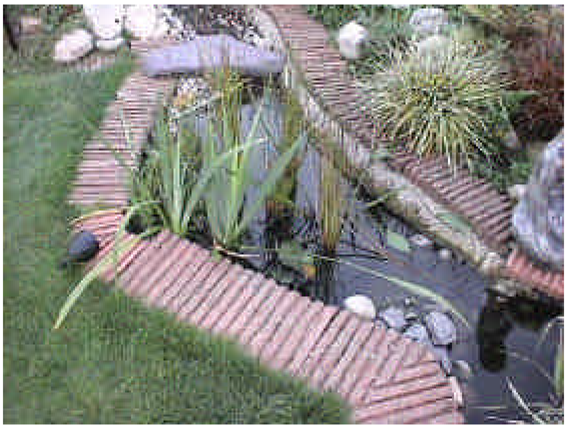
Also available apparently is a Block Filter Extension. This is a block of foam which can be attached to the front end of the Cascade pump as a pump pre-filter. I am unsure whether this would be yet more ineffective expense.

Disclaimer: You will in all likelihood invalidate your warranty if you perform such butchery to your pump cage!

On the Bog

The next thing to fix up is the bog-area of the stream. If you remember, like fools we had removed all the overgrown Water-Musk. So we got some new clumps of Common Reed or Norfolk Reed (Phragmites australis) which is a top performer because not only has it got a phenomenal growth rate in the right conditions, but it also oxygenates the water; essential for many of the bacteria that need oxygen to sustain them. Here we have re-planted the reeds, and some other varieties of plants to get our natural "vegetable filter" going again.

Before new planting...



...and after.

Cleaning the Bio-Filter

Change Your Attitude

Part of the approach to achieving a healthy pond is to appreciate the way nature works. In the beginning my own mental approach was wrong. I wanted longer times between cleaning the filter, and was getting annoyed at how often I was having to clean the pre-filter. Now that I understand the complete life-cycle in a pond, my attitude has changed and I now appreciate the importance of cleaning the filter system before it gets blocked up, and before the solids start to decompose. I also now accept that in any filtration system, regardless of size it is a simple basic fact that the pre-filter would not be doing its job if it didn't become blocked up. I have switched my thinking from one of becoming annoyed at the prospect of regular cleaning being a chore, to that of enjoying the knowledge that I personally play a vital part in the chain of events that helps to make my pond clean and healthy.

So what needs to be done?

Every 2 days I clean the system. 2 months after I finished my project I still clean the pre-filter every 2 days due to my changed attitude, although I have found that now that I have clear water I can in fact leave it for a week without cleaning.

The Skippy site says NEVER to clean the bio-filter media itself - LEAVE IT ALONE!

I have yet to see whether this is practical, but I intend to keep to their advice. The only cleaning I will be doing is to flush out the settlement chamber using the main drain pipe every couple of days. (On this note one other modification I might make is to add either a manual valve, or automatic non-return valve to prevent the water syphoning back into the pond when I turn off the pump - Stop press! I have found that my venturi now does this job for me, see the “Was it worth it” section of the Venturi page for more details).

Effectively that drain pipe that tips over is a simple but effective method of emptying out the bottom of the big plant pot.

If you examine the pictures you will see that the white T-piece swirler pipes go through and below the plastic garden sieve. The garden sieve holds the filter media away from the bottom of the pot, and creates about a 2 inch space at the bottom of the bio-filter where all the crud can settle out into the bottom, and the circular swirling action of the incoming water coming out of the swirler encourages the muck to go into the centre, and then gravity makes it settle out and go down the plug hole into the shower drain where it settles until I next empty the bio-filter.

When I empty it, because the main drain pipe is a decent size bore, it means the water can really rush out fast, and this brings all the muck out very quickly. In the first few seconds first some slightly messy water comes out, followed quickly by a thick gloup of very dense messy water (fish crap, algae, small particles of blanket weed), then the water flows reasonably clear again.

Most times (perhaps every 1 or 2 days) I just empty out for a few seconds (with the pump still running because the swirling action helps clean out the bottom) so as not to lose too much water, whilst perhaps once a week I turn off the pump and let it drain until no more water comes out (but of course like this several gallons of water are dumped, which sometimes requires a top-up in the pond).

This helps do a sort of reverse flushing action through the filter media. Then before I put the drain pipe upright again, I turn the pump back on, and let it swirl the last remaining crap out of the bottom, then raise the drain pipe back up and clip it back into place, so it fills the bio-filter and operates normally.

This whole process can be done very quickly. 30 seconds for a part flush, and maybe 5 minutes for a full flush while you turn off the pump, empty the contents into a bucket to fertilise your garden, turn the pump back on and refill the bio-filter.

I flush out the settlement chamber via the main drain into a bucket of water. One bucket is usually enough. I then clean the foam from my Bio-Force pre-filter by removing it and giving it a good squeeze and rinse several times in the bucket of water.

First I unclip the pipe, water starts to overflow.

Next I rotate the pipe forward and it empties into a bucket or on the garden.
Only once has the pipe accidentally come out of the bottom drain.

The biological media in the main bio-filter should only be removed and cleaned if it really needs it (i.e. if it is has solid waste on it - don't mistake this for healthy looking good bacteria gunk! You'll get to know the difference), and this should always be done in a bucket of the pond water. Changing too much water and cleaning too much of your biofilter will kill a lot of the bacteria resulting in yet more phytoplankton and green water.

Under no circumstances should you clean the biological media of the bio-filter using water from the hose! It is also advisable not to clean the mechanical "waste solids" pre-filter with tap water for the same reason;

The low temperature and chlorine content of tap water will kill off the nitrifying bacteria of the bio-filter, leading to severe water quality problems. The bio-filter will be dead and will have to start its maturing process all over again.

Conclusion and finally the Venturi

That completes the construction of the main bio-filter. It will take anything from 6 to 8 weeks to fully mature and become effective, and Skippy's say the cycling of the various processes may result in the green water going away, then re-appearing a couple of times.

One thing I have strictly adhered to is not to put any commercial algae reducing solutions into the pond. Neither green-water nor blanket-weed control solutions. I want to see exactly how well the bio-filter works, without any assistance other than natural processes, and plants. Also as mentioned earlier the UVC lamp in the Bio-Force is not connected, so also has no effect on the final results.

During the first couple of weeks after building my filter, not a lot happened. It was still pea-green and murky. I think this was partly due to the various modifications and tweaks I was making here and there, stopping/starting the system, pulling it apart, then putting it back together again, coupled with a lot of disturbance to the planting and cleaning out blanket weed by hand, which in itself causes sediment to cloud up the water.

The fish love it when I get my shirt off, and I reach right deep into the pond and dig around with my hands. They have got quite used to this behaviour from me, and come right up between my hands, looking to see what grub I might have disturbed from the bottom and sides.

I really need to just leave the pond and filter to settle down, but with the pump and pre-filter needing constant attention I just kept on messing around with it. For the first couple of weeks the pre-filter needed constant cleaning out.

It wasn't until I added the Venturi that suddenly everything started to happen.........

So the next step is to show you the venturi.

HOW TO BUILD THE VENTURI

This page covers the following topics:-

- **What is a Venturi?**
- In-Pond Venturis
- Mini Bio-Filter Venturi
- Water Turnover & Pressure Points (pump power)
- **Design Ideas** (initial resources and design diagram)
- How to build the Venturi
- **Finished Venturi** (look at the final working version first...)
- Earlier Prototypes (..... see the mistakes I made)
- Back to the Drawing Board!! (the reasons they failed)
- **Was it worth it?**
- **Update for 2005**
- Cleaning
- Venturi in da Pond

A What?

A **venturi** is a device that injects air into your pond water.

It is made very simply from pipework and has a restrictor inside and an air tube which extends above water level (you can see a diagram below). Water is pumped through the venturi, and the restrictor creates a vacuum that sucks air in from the tube above water level, and then mixes with water inside the venturi to cause bubbles that aerate the pond water. It is used to improve aeration and movement of water in the pond and **increase the oxygen level** in the water.

To the right is the final version of my DIY mini bio-filter venturi being tested without the filter media in the tank. Plenty of bubbles!

In-Pond Venturis

Normally a venturi is used directly in the main body of the pond, to provide oxygen and water movement for the benefit of the fish (some current to swim into). However I thought that a venturi dedicated solely to the bio-filter would provide it with additional oxygen, which "aerobic bacteria" require in order to live and work efficiently.

Some experts don't recommend venturis, as they can be inefficient devices because it forces the pump to push water through a restrictive venturi tube. Not only can the airflow produced usually be too small unless the device is placed right at the surface, but the final pump flow rate can be reduced by as much as 2/3rds! This means you would need a much bigger pump to power the system than required, just to power the venturi. This increases the initial cost of the pump, the running costs, and can reduce the life of the pump. This is true of "in-pond" venturis.

But venturis come in all types and sizes for different purposes. Industrial strength venturis, pumped using large electric motors for use in reservoirs, sewage farms, and water treatment plants, down to smaller scale for use in ponds. Venturis are also used to create the petrol/air mix in petrol engine carburettors.

When used directly in the pond, a venturi does require a considerable force to create good water movement, and a reasonably high pressure to "squeeze" the water and air together so making thousands of very fine tiny bubbles. Click here for a more heavy-duty venturi design specifically for use directly in the pond.

Note: My venturi is intended to help oxygenate the bio-filter, not the pond. You might consider having a seperate larger venturi fed from another pump dedicated to aerating the pond itself. To understand why it is a good idea, learn a little more about **oxygenation** at this link: http://home.att.net/~oxymax/aerate.htm

Mini Bio-Filter Venturi

For my purpose I don't want a powerful jet pushing into the bio-filter because it would disturb the filter media too much. All I need is a gentle flow of water with air bubbles, 24 hours a day, to help improve the oxygen level in the bio-filter. However the pressure in the device has to be sufficient to create the "venturi" effect in the first place.

Alternatively I could have purchased an electric air-pump, a length of tubing and a couple of air-stones to put in the bottom of the bio-filter. However, a venturi can be contructed easily, for virtually no cost, and has no moving parts to wear out, while an air-pump would have been another £10 or £20 depending on its size.

Since I had some piping left over after building the bio-filter I thought I would give it a go.

After building my venturi I agree that the pressure has been reduced, but only very slightly, more like just one quarter. My waterfall and stream which follow and are gravity fed from the bio-filter, still have a nice convincing flow.

Water Turnover & Pressure Points

The most important thing to remember with waterfalls and venturis is that it is not only the stated flow rate which is important, but the **wattage** of the pump. There is a big difference between a 2000 galls/hour flow rate @ 95 watts and a pump delivering 2000 galls/ hour @ 220 watts. The former is classed as a water mover, and whilst excellent for filtration flow, may not have sufficient power for a venturi or waterfall where back pressure and head are significant factors. The second pump mentioned would deliver the rated flow, overcoming back pressure and would pump up to considerable heights as it is more powerful, but of course more expensive to run.

My pond is only about 400 gallons (as mentioned before I am not a large-scale koi-keeper, I just want to improve the quality of my water). The Hozelock Cyprio Cascade pump I have can pump 4000litres per hour (or 880 gallons per hour) at its maximum rated capacity, and 616 gallons/hour at 1 metre head.

Design Ideas

The venturi detailed here **went through several test phases and rebuilds before it was functioning as desired**. I will show you the final design first, then later on I go over the earlier prototypes which didn't make the grade, and why they didn't work!

First I started out searching the Internet for information on how a venturi is constructed. I came across the following page and basic design which I tried out first:-

http://www.whom.co.uk/pond/venturi.htm

The design looked simple enough, but I found that my pump pressure was too weak for the size of piping suggested (3/4" pipe), because really the purpose of the venturi suggested at the above site is intended for a good strong flow into the pond itself.

I also found the following novel illustration of the principles and pressures involved in venturi design, and although probably beyond our humble purpose of aerating pond water (it is aimed more at engineering techniques for precision venturis and demonstrates the mathematics and pressures), it is quite interesting to look at because it is an interactive Java Applet which you can play around with! Give it a go!

http://www.ce.utexas.edu/prof/kinnas/319LAB/Applets/Venturi/venturi.html
With kind permission and courtesy of Prof. S.A. Kinnas, Ph.D., Ocean Engineering - Ocean Eng. Group, EWRE, Civil Engineering, University of Texas, Austin.

During the first three weeks of my bio-filter being in action it didn't really get much chance to build up any bacteria. I just wouldn't leave it alone, because I was taking it to pieces every 3 or 4 days to experiment with different configurations of piping and air-inlet pipe sizes in my efforts to get the venturi operating nicely.

How to build the Venturi

The final configuration is as shown in the diagram below. It is fashioned out of 22mm UPVC water pipe, with a corresponding 22mm T-piece. The central cone shaped "restrictor" hole is fashioned out of - wait for it - **plasticine**! Yes, I used ordinary kids plasticine because it was dead easy to mould while warm, and yet when it is cooled by the water it becomes stiff enough not to lose shape.

The restrictor hole cone shape was carefully formed in the plasticine by using a 10mm drill bit hand held (not in a drill!), first by rotating in a drilling fashion to make the initial hole straight through. This had to be done in small stages because the plasticine sticks to the drill bit, so you have to drill a little, remove and clean the bit, and repeat several times until you're through.

Next, again using the drill bit, constantly and slowly rotated, held loosely in your fingers, rotate it in a circular conical see-saw kind of motion with its axis at the centre of the T-piece, so that the plasticine is slowly squished out from both ends and then excess carefully cut off with a modelling knife. You have to be careful to make sure the excess plasticine is trimmed sufficiently far back into the T-piece because if you don't, when the 22mm piping is push-fitted into the T-piece, it will squish the plasticine in again so ruining the shape of the cone just created. You may have to repeat the process several times:- mould, shape, trim excess, until you are happy with it.

I would recommend not making the middle aperture larger than 10mm initially, so that the increase in pressure causes the velocity of the water to be quite fast as it goes through and passes the air-intake, so causing a good strong vacuum. Its easy to squish plasticine out, but not so easy to put it back in again without having to totally remake the restrictor. Only if the water pressure is reduced too much on the exit side should you consider increasing the diameter of the restrictor bore. It is surprising how much volume of water can pass through the venturi under pressure.

The air-intake pipe is made from electricians yellow/green coloured earth-sheathing tubing normally used to cover the earth-wire in domestic electric switch and socket connections. It was about the only kind of tubing that I could find readily to hand that was thin enough (about 3mm diameter) to cause a nice draw of air. This is because the vacuum in the venturi has to overcome the backpressure of the water trying to go up the tube. The bottom of the tubing was cut at a slight angle (about 20 degrees) to match the cone angle of the moulded plasticine, and it must be positioned exactly flush with the cone shape of the venturi for maximum effect. Again drilling through the plasticine vertically to accomodate the earth-sheathing is a bit tricky, because it squishes the plasticine out of shape again, so you might have to do some re-forming of the cone shape again, but this time with the air-intake pipe in place, while being careful that the plasticine does not get into the narrow air-intake pipe and block it up.

The plasticine is a little tricky to work with, but with patience you can do it. And like this you can re-form it until you have the best size and shape for it to work nicely.

Once you know what works you can, if required, re-fashion the venturi cone out of something more permanent like epoxy-resin. I did consider doing it with epoxy-resin at the start, but then I thought about the problems involved;

- How would you form the resin into the correct cone shape before it sets?
- Alternatively you could fill the T-piece completely with epoxy-resin to make a solid lump and drill after it has hardened, but then how do you drill a nice smooth cone shape in the resin if you don't have engineering tools?
- How do you put epoxy into the T-piece without getting it all gunked on the inside which after it has hardened would cause problems pushing the 22mm piping into the T-piece? We all know how incredibly sticky and stringy epoxy resin can be while working it, and how hard it is once set!

My main objective in creating the venturi was to try different things out until they worked, and what simpler way than to use good old plasticine? And if it works - well don't knock it! Anyway during the first couple of months use, so far the plasticine version has functioned perfectly well. The pre-filter prevents any large solid particles going through the venturi which might block or mess-up the shape of the plasticine.

Inspect the design diagram below and note the following <u>very important points</u> to ensure the venturi works:-

- The air-intake **must** be positioned on the **exit** side of the restrictor just after the narrowest section of the restrictor, **not** in the centre of it.
- The air-intake should be quite narrow (about 3mm) in comparison to the bore of the restrictor, so that the vacuum on the exit side of the restrictor can act easily to pull air in.
- The air-intake **must** be cut at a slight angle (about 20 degrees) to match the cone shape.
- The more narrow the bore of the restrictor is (start with about 8-10mm), the faster will be the flow of water through the restrictor resulting in a more powerful vacuum to suck air down the air-intake pipe, but the trade-off will be less water pressure out of the venturi into the bio-filter (this isn't a bad thing since we want a controlled flow through the bio-filter to give it enough Retention Time for bacteria to work), but this might also mean any water feature following on would not look very effective and it could put a strain on the water pump.

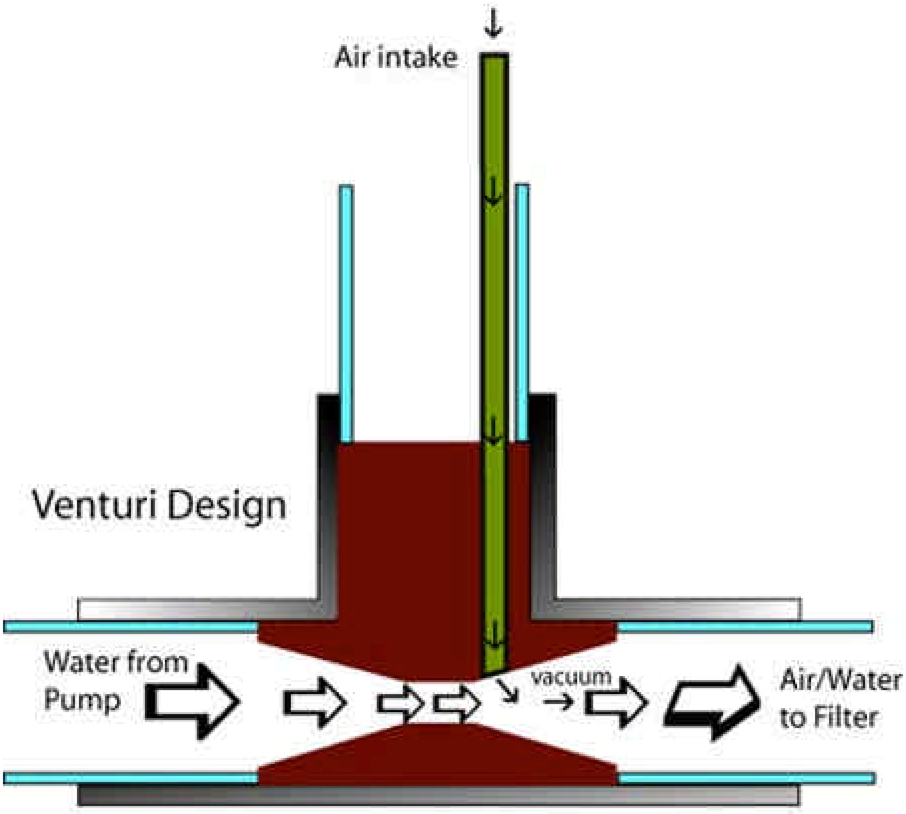


Figure 1. Venturi design.

Finished Venturi

The picture below shows the final venturi design in operation and as can be seen there are plenty of bubbles being output from the swirler at the bottom of the bio-filter. The black cap is just a suitably sized threaded cap fitted to the top of the 22mm pipework to protect the innards of the venturi.

Obviously the air-intake tube should not be pushed or pulled because it relies on the plasticine holding it in place, and its location in the venturi is critical. However as I explained it has now been in operation for 2 months with no problems. These pictures show the bio-filter with the filter media removed for testing.

And here it is with filter-media replaced, and the air bubbling up nicely through the media. In my earlier designs I had the venturi at the bottom of the bio-filter tank (see pics further below). Now with it at the top, it is much easier for me to remove it for inspection and cleaning, or even to upgrade to a better design if necessary.

With the finished design, after flushing out my bio-filter as a part of routine cleaning maintenance, when I turn the pump back on again there is some slight spouting of water out of the air-intake pipe due to large bubbles being pumped through from the pre-filter, but as the air bleeds out of the system and it settles down the venturi effect starts to work and pulls the air in properly giving a constant sucking sound and air bubbles are properly fed down into the bio-filter. So when you start it for the very first time, expect it to act a bit like a "coffee perculator" until the air in the pre-filter and piping has bled through and out!

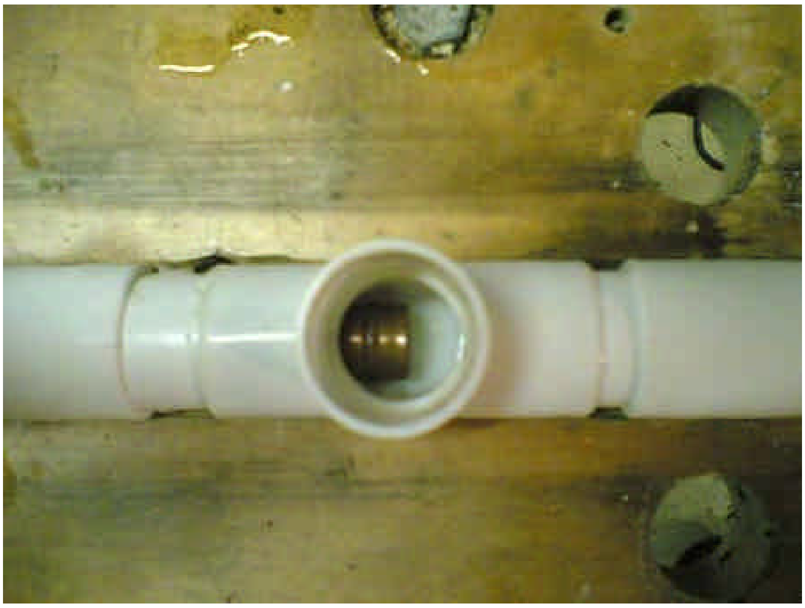
Put your ear next to the air-intake and you should hear a constant draw of air into the venturi, and of course should see the bubbles rising to the surface.

Earlier Prototypes - What didn't work!

This picture shows the very first design with the venturi T-piece positioned right near the bottom of the bio-filter, with a long upriser tube.

The first venturi design was attempted with a piece of copper tubing normally used to convert 22mm pipework to 15mm. It was glued in place with Fernox jointing compound.

When the T-piece was fitted on it was pushed on only far enough so that the narrow end of the copper converter was halfway through, so that a length of plastic tubing could be pushed down in front of the opening.



Another view.....(note that there is nothing else to fill/block this pipe or hold the narrower air-pipe in place - this was a mistake and one of the reasons why this design didn't work for me initially).

Looking into the exit or outflow end of the T-piece (below) you can see the plastic tubing in place, with its end cut at an angle and facing with the direction of the water flow (the water comes <u>out</u> of this end).

Here is the complete assembled (non-working!) venturi.

Back to the Drawing Board!!

Well the initial prototypes didn't work. There were several factors causing these designs to fail:-

1. The force of the water exiting from the copper tube was insufficient to create enough vacuum to suck the air **down** the clear plastic air-intake tubing. When the water was turned on and the bio-filter started to fill, it was drawing air in as expected, But as the tank started to fill, the level of water became higher, until eventually the vacuum was unable to overcome the backpressure of the water as it was trying to go **up** the air-intake tube instead!
2. There was nothing surrounding the air-intake tubing at the bottom of the 22mm pipework where it entered the T-piece, therefore nothing blocking and preventing water from rising up and around the air-intake tube inside the 22mm pipework. So the vacuum was also having to pull the water down in the main 22mm riser tube as well. It just wasn't going to happen!
3. The clear plastic tubing was too wide, so again the vacuum had too much volume of water to pull down the air-intake before it could even start drawing air in.
4. The copper tubing did not narrow enough, and didn't form any decent union with the air-intake pipe, which just flopped around in front of it with nothing to hold it in place.

5. All of these were exascerbated by the depth at which the venturi T-piece was located, about 10 inches underwater.

Three different types of tubing were tried. 8mm clear plastic tubing. 6mm tubing (blue), and finally electric Earth-sheathing which is about 3mm diameter.

With my earlier designs when I was testing them out (the ones that didn't work very well) I was listening with my ear right next to the air-intake to hear how well it was working, and you guessed it - I got an ear full of pond water! LOL.

Even though the Earth-sheathing was attempting to work better, it would once again stop as the filter filled up and the depth of water increased. Bear in mind that in this design there was still nothing to block the water coming up the main riser tube. No plasticine in this model.

So it was a case of "back to the drawing board" to have a rethink about the problems, and come up with a better design.

Was it worth it?

The final design shown at the start of this page works quite well. No doubt there is room for improvement, but.....

During the first 2 weeks of experimenting the bio-filter didn't really get much chance to settle down, what with me pulling it apart every couple of days to re-arrange the venturi. It is said that a bio-filter requires about 6 to 8 weeks to mature, while the bacteria builds up, and a balance is created in the ponds eco-system.

In the third week, with the early prototype venturis not working very well, there was very little happening, and while the water was beginning to look cleaner due to the pre-filter, it was still VERY green.

But in the fourth week, about 4 days after I got the final venturi design working mixing air into the water nicely, the water was starting to clear noticeably. Up until now the fish could only be seen clearly if they came within about 3 inches of the surface, any deeper and they became a green blur. But after 6 days of oxygenating the water going into the bio-filter the fish could be seen progressively deeper, now down to 6 to 8 inches, and the vivid green was weakening.

Now about 8 weeks after the whole bio-filter and venturi setup has been fully operational we can once again see our fish. The water is much clearer and cleaner. The bio-filter has healthy looking gunk in it, and the pre-filter does not seem to be blocking up as quickly - I still clean it regularly, but there is just not as much build-up of muck in it.

Now my pond is back to normal, with visible fish, thats a novelty!! And done the natural way without chemicals or ultra-violet lights. The big ghost-koi in the right hand picture is right at the bottom of the pond about 30 inches deep.

Another advantage of having the venturi just before the bio-filter is that if the pump is turned off, either for maintenance or due to power failure, **it prevents syphoning back into the pond**, because the air is drawn back down the pipe rather than the water, so immediately killing any syphoning effect. This is good on two counts; 1) it prevents any sediment held in the settlement chamber from backwashing right back into the pond, and 2) the bio-filter will not accidentally empty, so keeping the bacteria in water which although not flowing will at least keep the bacteria alive for a few hours until water flow is restored.

The success of the whole setup is not down to any one thing. It is a combination:-

- Re-adjusting mental attitude for regular cleaning of filters
- Oxygenating/aerating the water has a very positive effect on water quality, and efficiency of aerobic bacteria in the bio-filter
- Feeding the fish only as much as is required
- Cleaning other muck out such as leaves to minimise decaying matter
- Adding nitrate loving and oxygenating plants to increase bacteria breeding surface area elsewhere in the pond, and reduce the level of nitrate available to phyto-plankton.

Update for 2005

This year (Spring 2005) I have made a few changes to my setup. I have found that Ziks design (click here to see Ziks design) of venturi works very well in the top of my bio-filter, and it allows frequent and easy cleaning of the venturi - something I couldn't do as quickly with my design.

Conversely I have found that my design of venturi works very well in the pond itself (see further below).

The new-cut scourer pad filters in the bio-filter with the Zik design of venturi aerating the water.

Close-up of the Zik-type venturi, with a piece of green-scrubby acting as an air and noise filter.

The length of hosepipe fits snugly into the 22mm standard plumbing pipe. I have not glued it because it means its dead easy to remove the venturi to clean the teeth each day, although often it works for 3 or 4 days without any attention.

Close-up of the Zik type of toothed venturi. This really swirls and chops the air into the water as it passes, and makes quite a loud noise.

Cleaning and Adjusting the Venturi

Having the piece of green scouring pad as an air-filter is also necessary to cut down the noise, because when its going it really makes a good swooshing sound.

Each day I check the venturi for blockages from any muck that has come from the pump. I simply pull the green pipe out, and clean it off, making sure the teeth are good and clean. I leave the pump running while I do this (the water just overflows out of the white pipe while I clean the tooth-pipe).

When I put it back together I insert the the green pipe (making sure I've put the green side of the teeth facing the side that the water enters, with the white side of the teeth facing the way the water goes into the bio-filter), and slowly push it downwards until I see the water start to get sucked down, and then the venturi suddenly kicks into action again.

I then adjust it for the most powerful draw on air. I want a balance of allowing the best water rate through, but also achieving a good aerating effect.

The trick is to listen!

Push the green pipe all the way down until it touches the bottom, then lift it very slowly up until the venturi effect starts to lose power, then push it back down a bit. This allows the fastest water flow.

Now make a final adjustment by rotating the green pipe very slightly to offset its angle against a straight thru flow of water by about 10-15 degrees. You will hear the swooshing sound become slightly more intense, and this creates a swirling effect in the bottom of the venturi which really mixes the air into the water.

Venturi in da Pond

This is my design of venturi which I now use attached to a second Hozelock pump. This sits on a shallow shelf of the pond, just below the surface of the water. It creates a tremendous swirl of air and water, which the fish love to play in, and it creates very good circulation in the pond. This in itself helps keep muck and silt waterborne for longer so that the main pump can send it to the bio-filter.

And here it is in action...... (ugh, look at all that horrible slimy blanket weed, this was in early Spring before the biological processes in the pond had kicked in to reduce the algae).

Good Luck! And if you have any questions I am more than happy to help. Just mail me at
leisure@prior-it.co.uk

For great fish-keeping communities visit my favourite forums at:-

- The American Water Gardening Society
- Koiphen Forums

They are very friendly and knowledgeable groups of people who will make you feel very welcome.

Fantastic fish ponds is an excellent guide on how to build and maintain your own fish pond. Learn The Secrets Of The Pros To Have a Fish Pond Water Garden That Will Amaze Your Friends!