FishChannel.com
the website for fish lovers

Filtering Fish Ponds

An examination of the key element in fish pond filtration: the biological filter.

By Stephen M. Meyer

Ammonia and nitrite poisoning probably account for more pond fish deaths than any other single cause. There is really no reason for this, because the mechanisms of ammonia and nitrite poisoning and the methods for avoiding them are well understood. The simple fact is that once your pond is established — that is, after the first few months — and if you are managing things properly, there should never be any measurable concentrations of ammonia or nitrite in the water.

As I described in the first part of this article, it is useful to distinguish between a garden pond — one dominated by plants, where fish are a minor component — and a fish pond designed specifically to raise and display fish under high biological load conditions. In a garden pond, the quantity of ammonia produced each day by a few fish and by bacterial decomposition of organic matter is quite small compared to the volume of water. This small amount of nitrogenous waste is easily rendered harmless by nitrifying bacteria that live on the pond walls, plant stems and so on. Thus, as long as the fish load remains low and organic matter is not allowed to overwhelm the pond, the average concentration of ammonia will remain immeasurable and harmless.

To illustrate these points, let's take the example of keeping three orandas in a 400-gallon garden pond. We can estimate the approximate amount of ammonia they produce each day in one of several ways (see sidebar to the right).

Using the information in the sidebar, let's calculate the daily ammonia load. Each of the orandas probably weighs about 60 grams (just over 2 ounces). Assuming that they are healthy fish, at normal water temperatures each fish will produce about 15 milligrams of ammonia per day (25 milligrams of ammonia divided by 100 grams of weight times 60). The daily total ammonia production for all three fish is therefore 45 milligrams. Dissolved in a pond of about 1515 liters (400 gallons times 3.785), this would amount to 0.03 parts per million (ppm) of ammonia per day (45 divided by 1515). Keep in mind that 1 milligram per liter is the same as 1 ppm. If the pond is kept fairly clean of rotting organic material, ammonia from other sources will be insignificant and the nitrifying bacteria in the pond will be able to handle the daily ammonia levels without any problem. Because ammonia test kits for hobbyists do not register ammonia levels below 0.1 ppm, you would never obtain a measurable reading.

In a fish pond, however, the quantity of ammonia produced each day dwarfs the capacity of the pond-dwelling bacteria to detoxify the ammonia. As a result, toxic ammonia concentrations build up and the fish begin to weaken and die. Let's use a 1200-gallon fish pond with 42 koi averaging 10 inches in length as an example. Koi of this length may each weigh about 190 grams (6.7 ounces). Therefore, they each would produce around 47.5 milligrams of ammonia per day, totaling about 1995 milligrams per day for all the fish. This amount, dissolved in 1200 gallons (4540 liters) of water, would add about 0.44 ppm of ammonia to the water each day. In other words, the daily ammonia load produced in this fish pond is more than 10 times that of the garden pond noted above. Inasmuch as the population of nitrifying bacteria in the fish pond cannot manage this amount of ammonia each day, the concentration of ammonia will accumulate quickly to toxic levels, possibly exceeding 2 ppm after a week. In this pond many of the koi would become sick and die.

Because the natural biological processes present in a garden pond are not sufficient to detoxify ammonia in a fish pond, the only alternative is to set up a supplementary filtration system to do the job. There are two options for the pondkeeper: chemical filtration using ion-exchange or biological filtration. In my opinion, the former is poorly suited for continuous use in the hobbyist pond environment and therefore, for reasons I will describe, is best avoided.

Estimating The Daily Ammonia Load

It is often useful to estimate the daily ammonia load in a pond or holding tank. Fortunately, there are two fairly straightforward methods for doing this.

Unless a pond is totally mismanaged, the primary source of ammonia is the fish. On average, healthy koi and goldfish will produce about 25 milligrams of ammonia for every 100 grams of body mass. Thus, a 12-inch koi weighing 300 grams (10.6 ounces) will produce about 75 milligrams of ammonia per day. To determine the mass of your fish, you can weigh your fish on a scale or you can place each fish in a tub or container graduated in milliliters. Read the volume of water and then remove the fish — either by hand or with a net — without removing any water. Now read the volume again, which will be less than the first reading. The difference between the first and second readings is the volume of the fish in milliliters. The average density of a fish is 1 gram per milliliter. Thus, if your fish displaced a volume of 400 milliliters, it has a mass of about 400 grams, or 0.4 kilograms. By the way, this technique will work with any species of fish.

If determining the individual mass of your fish is too difficult, there is another option. First, using a kitchen gram scale, weigh the amount of food you offer your pond fish each day. The weight should be recorded in grams. If the protein content of the food is between 30 and 40 percent (standard goldfish and koi pellets), multiply the total weight by 25. (If the protein content is substantially higher than 40 percent, multiply by 30, and if it is significantly less than 30 percent, multiply by 20.) This gives a good estimate of daily ammonia production in milligrams per day, assuming that the food you feed is the primary diet of the fish. For example, if your fish pellets are 36 protein and you feed about 30 grams per day to the fish in your pond, the quantity of ammonia produced in the pond each day will be about 750 milligrams.

Ammonia Removal Via Ion Exchange

Ion exchange is a chemical filtration process that removes the ionized form of ammonia (ammonium) from pond water by swapping it for a different chemical ion in the ion exchange medium. The two forms of ammonia, ionized and un-ionized, are explained in the sidebar to the right. The ion exchanger removes the un-ionized, and far more toxic, form of ammonia — free ammonia — indirectly. Because the proportions of the two forms remains constant at a given pH and temperature, removing one from the water causes some of the other to convert.

In ponds, natural zeolites (which look like little chips of cement) can be used as an ion-exchange medium for ammonia removal. The amount of zeolite you will need depends on the ammonia production rate in the pond and the pond volume. Zeolites also vary considerably in their adsorption capacity. A safe average estimate is to assume that approximately 1 milligram of ammonium can be adsorbed by 1 gram of zeolite. Accordingly, the fish pond described above would need 1995 grams — or almost 4.4 pounds! — of zeolite to handle just a single day's ammonia production.

In order to use zeolite for ammonia removal, pond water must be pumped through the zeolite medium at least once every two hours. I have visited ponds in which bags of zeolite were just sitting in the pond water, providing almost no filtering effect. The hydraulic load — the volume of water pumped through the zeolite per unit of surface area — necessary to provide adequate ammonia removal should be between 1 and 2 gallons per minute per square foot of zeolite medium.

Natural zeolites can be "recharged" in heavy salt solutions. This eliminates the need to buy dozens of pounds of fresh zeolite every week when the medium becomes saturated with ammonia. When a 10-percent salt solution that is several times the volume of the zeolite medium is trickled through the zeolite bed for 24 hours, approximately 75 percent of the zeolite's ammonia-removing capacity is reestablished. (Theoretically, zeolite could be 90 percent recharged by this process. In a pond setup, however, organic contaminants usually block some fraction of the medium's surface, preventing complete recharging.) For this reason, it is best to design a zeolite filter with at least 25 percent additional capacity. Therefore, in the fish pond we used as an example, this would mean increasing the zeolite quantity to 5.5 pounds to adsorb one day's worth of ammonia.

Unfortunately, there are several drawbacks to using zeolite in ponds. First and foremost, even moderate levels of particulate matter and dissolved organic carbon in the water significantly reduce ammonia ion exchange. Thus, the effective use of zeolite requires continuous and extensive mechanical and chemical filtration of particulates and dissolved organics. This is just not realistic in the average hobbyist pond that employs 100 percent recycling of water.

Second, if the zeolite medium is left in the pond filter for more than a week, a bacterial and algal film develops on the surface and severely blocks ammonia adsorption. More importantly, the zeolite bed can become a source of nitrite poisoning as nitrifying bacteria establish themselves on the bed and begin to convert the trapped ammonia into nitrite. Because the zeolite is removed and replaced every week or two, the bacteria that would ordinarily consume the nitrite do not have an opportunity to become established. If left in the filter for 30 days, the zeolite is actually transformed into a biological filter — but all ion-exchange ceases.

Third, because the addition of salt to the water will cause the zeolite to release the ammonia it has trapped, it is not possible to use salt for medicinal purposes in ponds with zeolite filters. Although you could remove the zeolite before adding salt, there would no longer be an ammonia removal system and the fish would suffer even more as ammonia levels increased.

Fourth, over time you are likely to add new fish to the pond, and the fish you already have will continue to grow. This means the daily ammonia load will be continually increasing. The zeolite filter, however, cannot adjust, and what was once a sufficient quantity of zeolite medium for perhaps seven days will soon shrink to five days, then three days and so on.

Lastly, there is the problem of what to do with all of the saltwater used to recharge the zeolite. You cannot pour it into the garden or onto the lawn, yet it must be disposed of.

In short, if want to use zeolite for ammonia control, you should not allow the zeolite to remain in the filter for more than a week. It should then be removed for recharging and replaced by an equal volume of recharged zeolite. For our fish pond this would mean swapping 38.5 pounds of zeolite weekly. Moreover, it is necessary to test the water for ammonia and nitrite every couple of days to make sure that the zeolite is still adsorbing ammonia. In my opinion, this suggests that while zeolite may be useful for temporary ammonia control in ponds and holding tanks, it is not the process of choice for continual use by pondkeepers.

Biological Filtration

A far simpler and more reliable process for the continuous control of ammonia in ponds is biological filtration. Biological filtration actually detoxifies ammonia using two types of nitrifying bacteria to do the work. The first bacteria convert the ammonia to nitrite, after which the second bacteria convert the nitrite to comparatively nontoxic nitrate. This process is known as nitrification or the nitrogen cycle. You need do little more than provide the bacteria with hospitable surfaces to grow on and make sure that a continuous flow of pond water loaded with ammonia and oxygen is pumped through the filter.

Ammonia And Nitrite Toxicity

There should never be a measurable quantity of ammonia in a properly managed pond. In other words, total ammonia should always be below 0.1 ppm. Nevertheless, there are times when ammonia levels might rise temporarily and it is good to know when real problems are likely to start in the pond.

Ammonia in water comes in two forms: ionized ammonium and un-ionized (free) ammonia. This distinction is important because it is the latter that is most toxic to fish. I recommend that average levels of free ammonia never exceed 0.005 ppm.

At a given pH and temperature, the relative amounts of these two forms of ammonia stay in constant proportion. As pH goes up, or as temperature increases, the relative proportion of free ammonia increases. For example, in a freshwater pond with a pH of 7.0 and a temperature of 77 degrees Fahrenheit, the percentage of free ammonia is 0.55 percent, with ammonium comprising 99.45 percent. However, as pH and temperature change, so do the relative concentrations of the two forms of ammonia. At a pH of 8.0, free ammonia makes up 5.28 percent of the total ammonia, while ammonium drops to 94.72 percent. In both cases, if you were to remove one form of the ammonia, some of the other form would convert in order to maintain the proportional relationship.

Table I show the limits of safe levels of total ammonia (the ammonia measured with a test kit) in your pond as a function of pH and temperature. These total ammonia limits correspond to a maximum free ammonia concentration of 0.005 ppm.

Similarly, there should never be any measurable nitrite in your pond. Whenever nitrite levels begin to creep up above 0.3 ppm, you should consider water changes to reduce the concentration. Adding salt to your pond at a rate of 1 pound per 120 gallons will protect your fish from nitrite poisoning.

Indeed, a biological filter is little more than a water-proof box that holds the medium on which the bacteria grow. There are many ways to construct such a filter. Some people build them out of concrete, others use trash pails. There are two kinds — submerged and trickle biological filters. In a submerged filter the filter medium is always under water, whereas in a trickle filter the water passes across the medium. There are, in fact, hundreds of variations of these basic designs. Most work well. In the limited amount of space here, let me offer some general design principles that are common to the best filter systems.

There are many variables that determine the optimum characteristics of a biological filter for a given pond setup. Fortunately, they can be reduced to a few key considerations in order to give you a good approximation of what your biological filter should look like.

The most important consideration by far is the quantity and quality of the surface you provide for the nitrifying bacteria to inhabit. The material that fills the filter box and on which the bacteria grow is referred to as the biological filter medium. I strongly recommend that you use 1-inch stone, 1- to 2-inch lava rock or one of the new high flow-rate plastic materials for the biological filter medium. Avoid using sand or pea gravel, which can be a maintenance nightmare. Of the three types of material, I find plastic medium to be the best. I use it exclusively now in all the filters I design and build because 1) it offers a high surface area for bacteria with a small volume of material, 2) it does not clog readily but is easily cleaned when it does, 3) it is light and easy to work with and 4) it has good water flow characteristics (lots of void space in the medium). The one drawback of plastic medium is that it is rather expensive.

Second place goes to lava rock. Lava rock is preferable to ordinary stone because it has more surface area per unit volume than ordinary stone, and it is far lighter. Large lava rock medium (over 1 inch) does not seem to clog as quickly as ordinary stone. Third place goes to standard stone medium. In any case, the designs presented here will work with any of the three materials I recommended.

Let's examine in more detail what occurs around the filter medium. There is a thin bacterial film that coats the surface of each piece of medium. In order for the nitrifying bacteria to act on the ammonia in a given volume of water, the water flow must come into contact with the bacterial film. The water must also be in contact with the bacterial film for a minimal period of time for complete conversion of the ammonia to take place. Thus, a very important design consideration is the contact time of the pond water with the filter medium.

Many variables can affect the contact time required for maximizing the effectiveness of nitrification in a biological filter: water temperature, pond volume, size and surface characteristics of the medium and void space in the medium, to name a few. A conservative method for estimating the volume of medium required to ensure a minimum contact time that yields 100 percent ammonia conversion for your pond is to divide the pond volume in gallons by 125. The result is the required medium volume given in cubic feet. In almost all cases, the filter will have extra capacity. In the case of 5000 gallons of water, for example, the filter box will need to hold about 40 cubic feet of medium.

TABLE I
Total Ammonia Levels (ppm) At Various pH And Temperature Values

Temperature (degrees Fahrenheit)		pH Values			6.5	6.7	
7.0	7.2	7.5	7.7	8.0	8.2	8.5	
50	8.4	5.7	2.8	1.8	1.1	0.8	
0.2	0.15	0.005			59	5.7	3.8
2.0	1.4	1.2	0.45	0.17	0.09	0.004	
68	4.0	2.7	1.4	1.1	0.4	0.3	
0.1	0.05	0.002			77	2.9	1.9
1.0	0.8	0.35	0.2	0.09	0.005	0.001	

Next you need to determine the flow rate of the pond water through the filter. This is a very important determinant of the average daily background ammonia levels in your pond (see the sidebar to the right). The fact is, the actual ammonia level in a fully recirculating pond is never zero — even if the filter design is so efficient in design as to ensure 100 percent ammonia removal. There is always some amount of ammonia in the pond water because the fish are continuously adding ammonia to the water, but the filter can only remove ammonia from that small portion of the pond water that is moving through it at any given time. So even as one portion of the pond water is being cleansed of ammonia, another part is being polluted. From this explanation it should be obvious that the greater the number of pond volumes moved through the filter each day, the lower the average ammonia level will be. (If the filter were not 100 percent effective in removing ammonia, the average level would be even higher!)

For example, let's assume that the 5000-gallon pond is stocked to the point where the daily production rate of ammonia is approximately 9500 milligrams. This means that about 0.5 ppm of ammonia is added to the water each day (9500 milligrams divided by 18,925 liters or 5000 gallons). If only 5000 gallons per day is pumped through the filter — that is, one pond volume turnover — the average ammonia levels will be 50 percent of 0.5 ppm: 0.25 ppm. You will always measure about 0.25 ppm in the pond water no matter how big the filter! Now, if the flow rate is increased to five pond turnovers per day, the average ammonia level will drop to 10 percent of 0.5: 0.05 ppm, at which point you will not obtain a measurable reading with an ammonia test kit. In other words, pond volume, filter volume and filter flow rate are intimately connected. In a properly designed system, the average ammonia level, while never zero, is simply too low to be measured with hobbyist test kits.

In order to ensure a reasonably low average ammonia level, you should design your filter to process at least 12 pond turnovers per day. Thus, one-half of the pond's volume will be pumped through the biological filter every hour. One full pond volume per hour (24 turnovers per day) would be even better, but the costs for the pump and electricity become prohibitive with very large ponds. To determine a rate of one-half pond turnover per hour, just divide the pond volume in gallons by 2. This will give you the flow rate entering (and exiting) the filter in gallons per hour. For a 5000-gallon pond with a flow rate of one-half pond volume per hour, you would want to pump 2500 gallons per hour, whereas for one full pond turnover per hour, you would need to pump 5000 gallons per hour.

With the volume of filter medium and the filter flow rate (pond turnover rate) decided, the third step is determine the surface area (the length times the width) of the filter box that holds the biological medium. Although there are an infinite number of combinations of surface area times depth that will yield a given volume, only certain combinations offer maximum filtration efficiency. In particular, you want to match the filter surface area to the flow rate entering the filter so that there is 1 square foot of surface area for every 1 to 2 gallons per minute of flow. This relationship of flow rate to unit of surface area — dividing the gallons per minute of flow by the filter surface area — is called the hydraulic load on the filter bed. Basically, by designing your filter for this range of hydraulic loads, you will ensure that the water moves slowly enough through the filter so that the ammonia and nitrite are completely removed, but not so slowly that water that has already had these substances removed is still sitting in the filter box taking up space.

Pond Turnover Rates
and Average Ammonia

You should calculate the turnover rate of the pond through the filter. This is simply the volume of water your pump moves per day (gallons per day) divided by your pond's volume in gallons. For example, if a pump moves 1000 gallons per hour, it would be pumping 24,000 gallons per day. With a pond volume of 5000 gallons, the turnover rate would be 4.8 pond volumes per day.

The turnover rate (4.8 is this case) determines the average ammonia concentration (the ammonia remaining in the pond after filtration). The average ammonia level will vary according to the number of turnovers per day.

The final step is to determine the depth of the filter medium in your filter box. Depth is simply the volume of filter medium divided by the filter surface area. Because we have systemized our filter design relating pond volume, filter volume, filter flow rate, surface area and hydraulic load, the depth of the filter medium will always be fixed at one of two values. If you have decided to circulate one-half the pond volume per hour through the filter, then the depth of the medium will always be 18 inches. If you decide on one complete pond volume turnover per hour, then the medium will always be 12 inches deep. Either of these depths will ensure good flow characteristics through the filter bed without making the filter too prone to clogging and channeling.

There are several other design considerations worth noting. Always build the biological filter to operate outside of the pond. Pumping water from the pond, through the filter and back into the pond allows for more efficient designs and fewer problems. Pond filters that are built directly into a pond are a continual source of operating difficulties and endless maintenance problems.

Some pondkeepers make their filters larger than my design recommendations would require. They do this to compensate for the partial clogging and channeling that occurs in the filter bed over time. At best, however, this strategy merely lengthens the time between clogging — clogging will still occur. With the possible exception of some designs of plastic medium, most types of filter medium will inevitably clog to varying degrees. Unless you have an efficient and effective way to clean the filter bed, it will eventually clog to the point where the filter is no longer working effectively. The result will be a sudden, catastrophic rise in ammonia in the pond.

If you choose to use plastic medium, removing accumulated material in the filter bed is easy. Simple back flushing with a hose is sufficient to clean the bed. When using stones or lava rock, a straightforward solution for cleaning the medium every few weeks is to include an air-blower system when building the filter. Essentially, this is just a network of perforated pipes that rests on the filter grid below the medium, with an inlet blower connection. When the blower is turned on, air is forced to bubble up through the filter bed, carrying away trapped particulate matter. The waste water carrying the freed solids is then directed to overflow into the garden, not into the pond! This material is an excellent garden fertilizer, but will only add to the biological load in the pond if returned there. A drain at the bottom of the filter will aid in removing accumulated particulate matter at the bottom of the filter box.

To help slow down the rate of clogging, the use of a settling basin, explained in the first half of this article, is highly recommended. By placing the basin so that pond water flows through it before entering the biological filter, you can reduce — but not eliminate — the rate of clogging.

Biological filtration consumes about 5 milligrams of oxygen for every milligram of ammonia converted to nitrate. Other bacteria that live on the filter medium consume another 3 to 5 milligrams of oxygen per milligram of ammonia converted. As a result, a biological filter serving a heavily loaded pond with high ammonia production will consume a lot of oxygen. Therefore, your pond filter system should include a means for aerating the water as it exits the filter. A common approach is to design the filter outlet so that it spills into an aerating waterfall or stream. The effect of water flowing over a series of rock or gravel cascades is to remove carbon dioxide from the water while adding much needed oxygen. The more "steps" in the flow path, the better. Water that falls from a great height directly into the pond may look dramatic, but the aerating effect is only marginal.

An alternative biological filter design — one that incorporates aeration internally — is the trickle filter. In this design, the medium is not submerged under the water. Instead, the incoming pond water is dispersed over the top of the medium via a network of perforated pipes or a spray bar. The water then trickles down through the filter medium and exits at the bottom. The biological medium in the trickle filter is always covered by a thin coating of water running over the surface, but the spaces between the medium material are not flooded. Aeration occurs in the filter bed as the water cascades down the medium surface, bringing air into the bed itself. A trickle filter requires exactly the same design parameters as a submerged filter for a pond of a given size and biological load. Contrary to popular opinion, a trickle filter is not intrinsically more effective than a submerged filter. The single advantage it offers over the submerged biological filter is superior aeration within the filter bed itself.

Operating Considerations

It takes about five to six weeks in warm weather (around 70 degrees Fahrenheit) for a newly established biological filter to reach full operating capacity. In cooler weather — below the mid 60's — it can take 10 weeks or more. Trickle pond filters will take longer than submerged filters to become fully operational in cold weather because evaporation on the medium surface results in further cooling. In any case, it is important to monitor ammonia and nitrite levels carefully during this period. Water changes might be required to keep levels within safe limits.

Once the filter is operating, it is essential that it be kept running continuously. While it is acceptable to shut down a submerged biological filter for several hours for cleaning, modification or repair, pond ammonia levels will certainly rise if it is left off much longer. A trickle filter, in contrast, is always in danger of drying out if the water flow is cut off (this is not a problem with submerged filters if water is kept in the filter chamber). Never let the biological medium dry out during maintenance.

In the fall, as temperatures become lower, the nitrifying capacity of a biological filter drops as well. The nitrifying capacity of a trickle filter is reduced at an even faster rate than a submerged filter. Fortunately, the ammonia production rates of koi and goldfish are also reduced as temperatures fall, and ammonia toxicity is therefore significantly less. As long as the flow of water through the filter is maintained, things should remain in balance. However, those of you who — like me — live in areas with very cold winters have no choice but to turn off the filter as freezing temperatures approach. If the pond is not overloaded, serious ammonia problems will not occur. Shutting down the filter will not harm the fish because they do not eat while over-wintering, and thus produce relatively little ammonia. Unfortunately, this does mean that you must restart the filter from scratch in the spring.

In the spring, there are numerous changes in the pond that can present problems, the result of the fish becoming active long before the biological filter reestablishes itself. I strongly recommend monitoring ammonia and nitrite levels closely during the spring. You should never allow the pH of the pond water to drop below 6.5. Besides the fact that most pond fish — particularly koi and goldfish — do not thrive in highly acidic water, nitrification is also inhibited as the pH drops. If you have soft, acid water in your area, you should consider adding a mesh bag of crushed oyster shells to the pond filter. This source of calcium carbonate will increase the pH and help maintain it there.

Be aware of the nonsense factor in pondkeeping. For example, in recent years, some silly pieces of advice have appeared in hobbyist newsletters, including the assertion that nitrifying bacteria need sunlight to thrive. This is ridiculous. In fact, sunlight actually inhibits nitrifying bacteria.

Finally, keep in mind that an active and healthy pond is a dynamic system. Success in raising koi and goldfish can ultimately lead to disaster if you do not adjust for the changing biological load. Fish grow, and, over time, what was once a low fish load, can become a high fish load even without the addition of more fish to the pond. With koi, for example, every time they double in length their mass increases by more than eight times! If you had five 4-inch koi in your pond last year and this year they have each grown to 8 inches, the fish load is not twice as much, it is eight times greater! Goldfish mass also increases much faster than body length, with wide variations among varieties. In mechanically and biologically filtered ponds, I suggest never allowing the load to surpass 2.2 pounds of fish per 265 gallons of water. This is approximately two 13-inch koi. Monitor your pond regularly. Measure pH, ammonia, nitrite and temperature.

There are innumerable variations on pond filtration. The goal of this two-part article has been to make you aware of the rudimentary concepts in filter design. It is important to keep in mind, however, that no filter system — no matter how sophisticated — can return pond water to pristine conditions. Filters merely slow down the decline in water quality. The best single thing you can do to maintain the kind of water quality in which your fish will remain active and healthy is to keep the fish load low. The lower the load the better. Your pondkeeping goal should be to see your fish thrive and live out a full, normal life (up to 20 years for goldfish and well over that for koi), not to see how many fish you can cram into a pond for short periods of time.

Although pond filtration can allow you to maintain a fish pond with loads considerably greater than nature would otherwise allow, there are limits. As long as you stay within those limits, a pond filter can help you keep your fish healthy, and in doing so make your pondkeeping all the more enjoyable.

Part 1>>