The Water Garden

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May 2023 Newsletter

2023 Denver Botanic Gardens' Spring Plant Sale

By: Brenda Parsons-Hier

Denver Botanic Gardens' Spring Plant Sale, Thursday, May 11th, Friday, May 12th, & Saturday, May 13th

The Aquatics Booth will be located near Marnie's Pavilion.

For a site map, please go to:

https://www.botanicgardens.org/sites/default/files/file/2023-04/2023-SpringPlantSale-SiteMap.pdf

Whether it's your first ever houseplant or you're planting a whole garden, there's something for every gardener at the Denver Botanic Gardens' Annual Spring Plant Sale! Get advice and inspiration from expert horticulturalists while you browse fifteen different plant divisions: Annuals, Aquatics, Container Garden in a Bag, Fruits & Berries, Grown at the Gardens, Herbs, Houseplants, Perennial Classics, Plant Select®, Rock Alpine, Roses, Specialty Succulents, Summer Bulbs, Vegetables, and Water-Smart.

Important Details:

***Admission is free, but reservations are required**
***Tickets will not be available onsite**
***Membership does not guarantee a ticket to the event**
***Arrive early for the best selection**
***Last entry is 4:00 pm, the event ends at 5:00 pm**
***Bring your own wagon, cart, or wheelbarrow to transport plants**
***Credit/debit cards and checks are the only accepted forms of payment**
***Members receive 10% off purchases (must present proof of active membership)**

Free parking is available in the parking garage, accessible from either York Street or Josephine Street. Spaces are limited. Street parking is available, but please be respectful of the neighborhood and observe all parking restrictions.

Preview Party, Thursday, May 11th, 4:00 pm - 7:30 pm SOLD OUT

Friday, May 12th, 8:00 am - 4:00 pm
Reservations are required

Saturday, May 13th, 8:00 am - 4:00 pm
Reservations are required

For reservations, please go to:

https://catalog.botanicgardens.org/DateSelection.aspx?item=4586

For a shopping guide and and sale information, including a list of plants for sale, please go to:

https://www.botanicgardens.org/sites/default/files/file/2023-04/2023-SpringPlantSale-ShoppingGuide.pdf

For questions or more information, please call Brenda Parsons-Hier at (303) 278-2106 or moose.4bph@q.com

Rocky Mountain Koi Club Koi Auction

By: Chris Goumas

The Rocky Mountain Koi Club will be hosting their annual Koi Auction on May 13th. The auction will be held at the home of Chris Goumas, Rocky Mountain Koi Club Newsletter Editor: 7378 Upton Court in Castle Rock. Please park on the street (mind the parking signs) and leave the driveway open for those loading and unloading.

Bidders' registration and sellers who have Koi or other items need to register between 9:00 am and 10:00 am. Bidding will start at 10:00 am or so. Auction will end when all Koi are sold. Bid numbers are $5. Bidders will be assigned a number and will be able to participate in the auction. You can sign up at the Auction or here:

https://www.rockymountainkoiclub.org/event-5252452/Registration

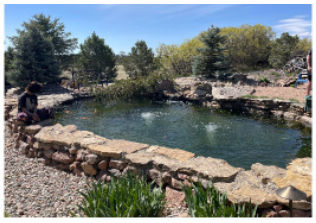
We will accept cash, check, or credit cards for payment.

Sellers are suggested to donate 50% of the sale to the RMKC. Payment to the sellers will be made after the auction.

Anyone can bring Koi for auction. Koi should be in bags, if you don't have the ability to do that, we will offer a bagging service for $5/bag. Bags can have more than one fish but each bag will be auctioned with all its contents (i.e., if you have 2 fish in a bag, we won't auction them separately).

The general public is welcome to attend. Help us out and spread the word and let's see how many people we can get there!

For additional information or questions, please contact Chris Goumas at chrisgoumas@yahoo.com or (440) 823-6301.



Photos of Past Koi Auction (photos courtesy of Chris Goumas)

Plant Swap, Thursday, May 18, 2023

By: Vicki Aber

It is almost time for the annual plant swap. This is a very fun event. We get to eat, trade plants, and learn stuff.

The Swap will take place on Thursday, May 18th starting at 7:00 pm. The location this year will be at my house: 8046 Parfet Way, Arvada. I will apologize in advance for how my yard will look. We are hopefully getting a new liner installed in one of our ponds on May 6th. Of course, mother nature may have other plans. There is another large pond and a large yard to spread out in, so it should be okay. Please park on the street and enter the backyard through the gate, nearest the driveway. Just a friendly reminder, please leave your pets at home.

We will start at 6:00 pm with one of our signature pot lucks. Everyone should bring a dish of their choice, be it an appetizer, salad, side dish, main course, or dessert. The Club will provide drinks. There will be plenty of time for socializing during this portion of the meeting.

After the meal, we will proceed to the main event. Everyone will stand by the plants they brought. That person will talk about their plant's growth habit, hardiness, color etc. This will help the new owner of the plant to be successful. After everyone has had an opportunity to talk, we start the swap.

At the beginning, you are limited to getting one new item for each item you brought. After everyone has had a chance to do that, we open it up for people that didn't bring anything and people that would like more items than the number they brought. It sounds chaotic but usually it isn't. When you have chosen all of the items you want, remember to place them away from the area of the swap so they don't get selected again!

What is okay to bring? Of course, water plants are our main focus but you can also bring terrestrial plants (we all have gardens beside the water kind), house plants, decorative pots, equipment, etc. You are not allowed to bring your firstborn for trade.

Hopefully, at the end, everyone goes home happy and has the chore of planting ahead of them.

We hope to see you there.

If you have any questions or need additional information, please contact me at (303) 423-9216 or docvicki@msn.com.

Colorado Water Garden Society Plant Sale to be held on Sunday, June 4th

By: Vicki Aber

Our Plant Sale is coming up soon (Sunday, June 4th)! The Plant Sale Committee has been working hard behind the scenes to select plants for the Sale. We hope to have a great selection again this year. Current CWGS members can start shopping at 9:00 am. Non-members will have to wait until 10:00 am to start shopping.

The Sale will take place at The Hudson Gardens & Event Center located at 6115 S. Santa Fe Drive in Littleton. The Sale will be located on the patio of the Business Office/Residence.

There will be both hardy and tropical aquatic plants offered, as well as Pondtabb fertilizer tabs.

We need donated plants. If you are dividing plants from your own pond and have extras, please save those extras and consider donating them to the Sale. If you have plants to donate, we ask that you please drop them off by 10:00 am on Saturday, June 3rd. That way they can be labeled and priced accordingly.

We are always needing volunteers for the Sale. We will need help on Saturday, June 3rd starting at 9:00 am. We are looking for help to sort plants, price plants, and stage them for the Sale on Sunday. On Sunday, June 4th starting at 8:00 am, we are looking for help staffing the Sale. We are specifically looking for help to assist customers with plant selections, talking about plant characteristics, Club marketing, and help at check-out. After the Sale is over, we need help with clean up.

If you are able and would like to help with the Sale, please let me know. You can call me at (303) 423-9216 or email me at docvicki@msn.com.

June 2023 Pond Side Meeting

By: Teresa Burkert

Ready for a relaxing afternoon spent with fellow water gardeners? Have any questions about ponds, plants, or containers? Join us to share good food, ideas, and gardening discussions!

Join us for our first Pond Side Meeting of the year. The June Pond Side meeting and potluck will be held on Saturday, June 17th from noon to 3 p.m, at Front Range Gardens, 10195 Wadsworth Blvd. in Broomfield.

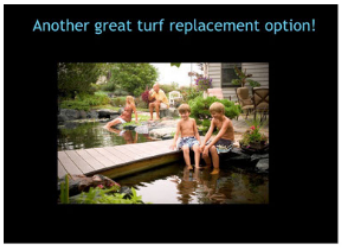
A tour of the greenhouses where many of their extensive annuals and perennials are raised will be provided by knowledgeable and friendly staff. Learn more about them at https://www.frontrangegardens.com/

Mark it on your calendar, as you don't want to miss this opportunity.

2023 Get Wet Event — A Recap

By: by Teri O'Sullivan

Get Wet 2023 (photos courtesy of Bill Powell)



True Pump & Equipment Presentation Slide (photo courtesy of Tim Boettcher)

Slide from Chris Peters, Bio/Environmental consultant (photo courtesy of Chris Peters)

Young Beaver (photo courtesy of cottagelife.com)

As part of CWGS's mission to 'provide education and information to the general public about water gardening', our 43rd Get-Wet kick-off meeting, co-sponsored by the Denver Botanic Gardens and held April 20th at Gates Hall in the Boettcher Memorial Center, was a great success.

Given the current drought environment and growing concerns about recent bans on new pond / water feature construction, impending water use restrictions and their potential impact on our water gardens and ponds, this year's topic: "Can Water Features Be Xeric," was of significant interest and upwards of 40 people including CWGS members, non members, pond builders, and landscapers, were in attendance.

A lovely slide show interspersed with water-themed quotations, poetry, Haiku, and examples of water features, plants, Koi, and xeric combinations, greeted people as they arrived and found a place to sit.

Our panel was made up of experts in water conservation strategy, water-wise policy initiatives, and representatives from the pond construction business, and included: Tim Boettcher, President of True Pump & Equipment, Bea Stratton, Demand & Efficiency Planner from Denver Water Resource Strategy Department, Lindsay Rogers, Policy Analyst from Western Resources Advocates, and Chris Peters, a Bio/Environmental consultant, formerly with Colorado Parks and Wildlife.

For more information, please go to:

https://www.truepump.com/

https://www.denverwater.org/about-us/how-we-operate/strategic-plan

https://www.denverwater.org/your-water/water-supply-and-planning

https://westernresourceadvocates.org/we-save-water-and-protect-rivers/

Some of the "Transformational Thinking" goals and take-aways from the panel and slide presentations included:

***Thinking of Water as a Treasure* – something precious to be cared for, not just another resource to be exploited.**

***Including Private Property Owners as Creative Solution Partners* – as valued contributors to decisions & policy-making!**

***Engaging and Soliciting Landscape Professionals & Builders and other Stakeholders* for their ideas and concerns and including them in dialogue and policy making.**

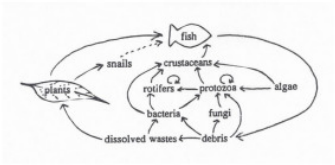
***Capturing Educational Opportunities to Bring Nature to the 'Home Classroom'* – via the backyard!**

Based on all the emails, follow-up calls, and comments we received by every one of the panelists, CWGS members, and several people in the audience we believe that each came away with a better appreciation of the Colorado Water Garden Society as well as the benefits and advantages of water features and ponds. Not just for their beauty, but also as an alternative to turf, a complement to xeric landscaping, and an increasingly important water source for the extraordinary variety of pollinators, beneficial insects, birds and other animals who take advantage of them.

As of this writing, Teri O' is planning to go-to-bat to get beavers, *Castor canadensis (God's amazing little engineering rodents) back to work in their native habitat building dams, ponds, wetlands, waterways, and cleaning up the mess we've made. And, at least two people are considering putting some kind of water feature in their backyard to replace their grass. In case you missed it, Denver's Channel 8 TV recorded the meeting and we are hoping it will be available to view within the next month.*

Basics of Biological Pond Filtration - Lecture for the International Water Lily Society Symposium in Atlanta, Georgia, July 31, 1995

Figure 1



A very simplified pond food web

By: James Allison

Basics of Biological Pond Filtration

Various things can make pond water cloudy and of poor quality:

• Decaying material in the pond e.g., dying plants
• Excreta from organisms in the pond e.g., fish waste
• Debris and soil washing into the pond
• Silt stirred up off the base
• Algae growth causing green water

Natural Filtration Processes

How does nature cope with this waste?

Much of the waste is removed by filter feeding organisms and browsing & grazing organisms:

• protozoa filter feed on fine waste and bacteria
• rotifers filter feed on fine waste and on protozoa
• crustaceans filter feed on debris, bacteria, rotifers, algae, and larger debris
• snails graze on live and dying plant tissue

Other organisms aid in the breakdown of waste e.g., fungi and bacteria are important for the effective decomposition of waste.

See Figure 1

Some of the final waste products from this process of decomposition are ammonia (NH3/NH4) and carbon dioxide (CO2). The purification process continues as these waste products are used by other organisms.

Nitrifying bacteria are present in the water and are most commonly found attached to surfaces within the pond and on the surfaces of debris particles. They convert ammonia/ammonium first to nitrite (NO2) and then the nitrite is converted to nitrate (NO3). These bacteria are particularly important in the breakdown of fish waste.

The nitrates are used by plants as a source of food (some plants can also feed on ammonium and nitrites) and in areas of the pond where there is little dissolved oxygen, denitrifying bacteria convert the nitrates back to nitrite and then to nitrogen gas. Higher plants and simple plants like algae, use the carbon dioxide as source of food. The submerged plants also release oxygen in the process of photosynthesis. This is a very simplistic overview of the purification process which leaves the water in a healthier state.

What about algae (green water and blanketweed – *Spirogyra adnate*)?

Crustaceans, such as water-fleas, feed on the free-floating algae and higher plants that shade out light and compete for the dissolved nutrients in the water that the algae feed on.

What about cloudy water?

Fine particles are clumped together by natural colloids occurring in the water and by filter feeding organisms. Much of the waste sinks to the pond base.

What about more unusual pollutants?

Very specialized bacteria are capable of breaking down most complex chemicals that enter the water, although they can take some time to do so. The next time the pond is polluted by a particular chemical, it will be broken down in less time. This has important consequences when ponds are treated with medications.

The Problem

If nature is so good at purifying the water, why not leave her to it?

We upset the balance by:

• Adding too many nutrients to the water – soil, fertilizers, fish food, etc.
• Making some ponds too shallow and with too low a volume for their area. This leads to temperature fluctuations which favor algae growth
• Adding too many fish and add them too soon. The fish eat the crustaceans that would feed on green water algae, they stir up the sediments, and they become stressed by build-ups of fish waste as there are insufficient organisms to break down these wastes entirely.
• Too many koi lead to them to eating more, eating messily, and eating plants, which removes one of the natural purifiers.

Filtration

This is where filtration can be brought in to help. Filtration is of two major types; mechanical filtration involves the physical removal of particles by various methods such as straining them out.

Biological filtration is simply taking nature's processes of water purification, containerizing them, and concentrating them. In many cases the mechanical and biological aspects of filtration can overlap.

Biological filtration is used very widely, throughout the world, in the processes of water purification for drinking water; and sewage/wastewater treatment. It is worth noting that in the last hundred years there has been intensive development of these processes and despite a great deal of common ground in the methods of treatment, there is no single best method of treatment. In the same way, the best type of biological filter for a given pond will vary according to the individual requirements of that particular pond.

Pond filtration has a lot in common with some of the simpler methods of drinking water and waste water treatment. Modern 'high-tech' methods of water treatment (e.g., activated sludge systems and chemical coagulation) may be technically more efficient, but the 'lower-tech' methods require less specialized monitoring and are more applicable to pond systems.

What to look for in a biological pond filter system

Whether you are purchasing a system off the shelf or building your own system, there are a number of things to consider.

Positioning

Small filter units can be placed in the pond but have a limited capacity and tend to clog rapidly if overloaded. Larger in-pond units are available, but can be cumbersome to handle and clean.

Under gravel systems positioned in the pond are cheap to install, and initially, are very effective, but they have no

effective means of pre-filtering and are very problematic if there is a pump/power failure. The difficulty of cleaning and maintaining such systems has made them less popular.

External filters are the best option for most medium sized pools. In their simplest form they are a single tank into which pond water is pumped, the water then returns to the pond by gravity via a larger pipe or down a waterfall.

In larger systems the filter can be set at pond level beside the pool. Water flows into the filter by gravity, through a large bore pipe set into the pool wall. Filtered water is then pumped out from the filter back to the pond. This method has a number of advantages and is particularly popular with koi keepers.

Pre-filtering

Pre-filtering involves the removal of larger solids from the water and is mainly a mechanical process to clean up the water before it passes to the next (biological) stage. This is important to avoid the biological part of the filter becoming clogged and smothered with large amounts of solids.

The first stage of pre-filtering takes place in the pond, without any effort on your part! Large solids will sink to the base of the pond in the process of settlement. In water garden pools these solids are probably best left alone on the base for infrequent removal at pond clean outs. Keep pumps raised up off the base so as not to disturb this layer. If convenient, the sediments can be siphoned out as waste once or twice a year.

In ponds with large numbers of fish, or with disruptive koi, the settled layer will not remain settled for long. In these cases, the settled solids are best removed by pumping them into the filer, or preferably, by removing them by fitting a bottom drain at the lowest point (s) in the pond.

Other types of pre-filtering involve the strainer on the pump. In some cases, it is possible to fit a larger strainer/pre-filter to the pump to reduce the frequency of cleaning. This may have some biological activity if run continuously, but the vigorous cleaning required tends to disrupt the filter organisms.

In simple single chamber pond filters, the water may pass first through layers of mesh, floss, or open cell foam – which can act as pre-filters. These should be cleaned when necessary to remove solids from the system. If they are cleaned cautiously in a tub of pond water rather than tap water, then they can have a biological function as well.

In more advanced multiple chamber filters, the first chambers of the filter are left empty to act as a further settlement area (e.g., vortex chambers) or filled with easily cleaned open media such as filter brushes or loose plastic media.

Biological Filtration

After the pre-filtration has taken place, the main biological filtration processes can continue. Unlike the pre-filter areas, the main biological sections of the filter should not be regularly cleaned or disturbed as this will upset the filter organisms. It is helpful if the filter is fitted with a drain to allow collected solids to be gently flushed from the filter area, without the need to stir up the filter bed.

The main requirements of the biological filter organisms are:

• A large surface area to attach to.
• A constant supply of water to bring in essential dissolved oxygen and the waste from the pond which acts as food for the organisms. In heavily stocked ponds and ponds in hot climates, some extra forms of aeration - over and above the general water movement in the pond - may be required.
• Stable conditions as free as possible from rapid changes e.g., in temperature, disruptive influences such as strong pond medications, chlorinated water, or exceptionally high or low pH values.
• Time to establish. Bear in mind that a whole community of organisms have to colonize the filter. Seeding the filter with active media from another filter or with a good commercial maturing agent can help enormously. In most cases, the filter will require 4 to 8 weeks to become fully functional, and the maximum capacity of the filter may take years to develop.

The large surface area is generally supplied by filling a fairly large filter chamber with an appropriate biological filter medium. There are a vast range of materials for sale, all with different advantages and drawbacks. As a very brief guide:

• Gravel – makes a cheap and moderately effective medium. Use a slightly angular gravel in a hard material with a coarse surface texture.
• Plastic materials – are very lightweight and some float. Well-designed materials have a fair surface area and are less vulnerable to clogging, but the surface areas generally fall far short of other media, and the smooth surfaces provide a poor foothold for some of the filter organisms. Filter foam and plastic matting can provide reasonable surface areas, but need good pre-filtering to avoid clogging. Foam can eventually disintegrate and may need replacing after a few years.
• Mineral type materials generally provide the best compromises between weight, surface area, texture, and cost. Types available include:
- volcanic lava rocks
- sintered fuel ash e.g., lytag or pozzolana
- sintered glass products, although some are expensive

These filter media can be used in a trickle type system, which increases oxygen levels. This benefits fish and algae, but acts as a detriment to the plants. However, with the fairly large flow rates required in pond systems, a submerged filter bed is, in most cases, the preferred option.

What is going on in the biological filter bed?

Many of the processes of the food web mentioned earlier are taking place in the biological filter bed. Each piece of filter media can be home to millions of beneficial bacteria and tens of thousands of protozoa. The way the filter is set up allows them to work efficiently, almost like a factory assembly line, with a succession of different organisms having major roles as water passes on through to the next layer in the filter bed.

The quantity of media required

The quantity of media required depends upon a number of variables. The larger the pond, the more fish being kept, and the more that they are fed, the bigger the filter bed will need to be. If a medium with a very high surface area is used, less medium may be necessary, but if the filter bed is made too small or uses a media that is too fine, it will become more vulnerable to clogging.

Nitrifying bacteria are surprisingly efficient once established, and even a small amount of filter medium may provide enough room for sufficient bacteria to deal with the nitrogenous wastes from fish. However, contrary to some opinions, nitrifying bacteria are not the only biological organisms of importance in the filter. The other types of bacteria and the protozoa and larger organisms in the filter all require plenty of room if they are to achieve their filtering potential and it is these organisms which are responsible for improving the clarity of the water.

In general, when it comes to filter media, more is better. More media and more types of media provide more suitable places for filter organisms to live. The greater number of organisms the filter contains, the better it will be

prepared to cope with sudden changes in loading, and if a power cut or medication disaster should wipe out 80% of the filter capacity, the remaining 20% will be more likely to cope with the calamity.

The depth of any filter bed depends on how fine the media is and how much surface area it provides. As a guide, a typical mineral media with a granule size of around 1/2" (12mm) could be used in a depth of 9" – 12" (22 cm – 30 cm). Finer media are best used in shallower beds and coarser media in deeper beds.

Flow rates

The flow rate through the biological section of the filter is critical if the filter is to work effectively.

If the flow rate is too fast, waste and solids can build up in the filter more rapidly than the filter can deal with and the filter will clog. Some manufacturers require their filters to clog to clear the water – in these cases, the filter is acting more as a mechanical strainer than a biological filter.

Fast flows can also wash dissolved wastes right through the filter before the organisms have had a chance to act. Strong currents can also dislodge filter organisms and wash them off the biological filter medium.

If the flow rate is too slow, the filter organisms may not receive sufficient oxygenated water and may not increase in numbers to the potential of the filter. Slow flows also allow waste and algae to build up at a faster rate in the pond than the rate the filter can remove them.

Guide

Putting figures on natural processes is never a precise procedure as nature is not too keen to be pigeonholed in this manner. The ideal flow rates and filter bed size will vary according to the situation, the type of media used, the temperatures, and numerous other variables. Nevertheless, here are some suggestions for flow rates for typical water garden ponds:

The filter should aim to treat half the pond volume every hour e.g., a 1,000-gallon pond should have 500 gph pumped through the filter. Heavily stocked fishponds and holding systems can benefit from a complete turnover of the pond volume each hour.

Treating one quarter of the pond volume every hour may be sufficient for lightly stocked ponds but a U/V unit may be required to deal with green water algae.

The flow rate through the surface of the main biological filter bed should be around 60 – 240 US gallons per hour per square foot (mean = 150 gph). The higher range of flow rates are only suited to very open media (with a high 'void space') or biological filter beds with very good pre-filtration.

So, what size of filter should you choose?

Combining the two formulas above should give you an idea of the size of the main biological filter bed in the filter system.

1) A 1,000-gallon pond requires a flow rate of 500 gph through the filter
2) 500 gph flowing through a filter bed at a mean rate of 150 gph/square foot results in a filter bed of 3.3 square feet e.g., a bed around 18" by 27"

Some manufacturers make big claims for their filters, but unfortunately in some cases more has been spent on the marketing than on the product design.

In general, bigger is better. Larger filters are not guaranteed to work better, as this depends upon the design and the types of media used, but larger filters will clog less rapidly and are likely to require less maintenance. If you cannot fit in a big filter, then a smaller one may cope if it is used in conjunction with a U/V unit to aid control of green water algae.

Other design points to look for:

* void spaces under media beds to allow waste from the filter organisms to collect
* drains to facilitate removal of this waste and other sediments
* a lid to keep light and debris out
* overflows to prevent filter flooding
* aeration or ventilation features
* easily cleaned pre-filters
* sturdy materials that won't warp with time
* convenient connections for hose/pipework

APPENDIX 1: KOI PONDS

All of the above information applies to koi ponds too, but as koi are messier and tend to eat any plants which might help in the balance of the pond, it is wise to make. their filters even bigger. Good settlement/pre-filter areas are particularly valuable.

Gravity fed, multichambered filters are the preferred method for koi pools, perhaps with a surface skimming facility. Water can be fed to the filter from a mid-water feed or from a bottom drain via a settlement tank. Full clarity can be aided with the use of a U/V unit. Blanketweed can be more of a problem in koi pools and may require chemical treatment. Regular removal of settled solids from the filter, and sensible feeding, can help to reduce this problem.

APPENDIX 2: FILTER MAINTENANCE

The maturation and efficiency of biological filters can be monitored by the use of readily available nitrite and ammonia/ammonium test kits. Very alkaline (pH> 9) or acid (pH< 6) water can upset filter activity. In both cases a series of partial water changes is the best remedial action.

High alkalinity is usually due to lime from cement work or excessive algae growth. Acidity normally results from build-ups of organic waste in ponds stocked with large numbers of heavily fed fish with few plants and few regular partial water changes. Addition of buffers can give some temporary improvement.

Pond medications, including some algicides, can upset filter activity. Safer types will not affect the filter too much and tend to have the most detrimental activity on the first few uses only. When using strong medications in the pond, isolate the filter from the pond, but keep it running by recirculating filter water.

In cold weather (temperatures below 46°F/8°C), the flow through the filter can be reduced to a half or less of the normal rate, to prevent excessive cooling of the pond. If the filter starts to freeze up, it can be turned off. Providing it is turned back on as soon as it thaws, a sufficient number of the filter organisms will survive; although it is wise to drain stagnant water as waste before restarting the unit. Alternatively, drain and rinse the unit when winter arrives and restart it in the spring. The filter will need more time to mature in this situation.

Further reading:
There is no one book that covers pond filtration in great detail, but a number of books do have sections on filter

design or construction:

"The Practical Encyclopedia of Koi", Salamander Books, 1989
"Water in the Garden", (James Allison) Salamander Books, 1991

A number of journals and magazines often carry articles on pond filtration:

"Koi Health Quarterly", https://koiorganisationinternational.org/koi-articles/complete-koi-health-quarterly-100s-good-articles-indexed
"Practical Fishkeeping Magazine", https://www.practicalfishkeeping.co.uk/
"The Water Garden", https://www.colowatergardensociety.org/ **(must be a member to access Archive)**
More general coverage of biological filtration can be found in the following:

"Seawater Aquariums, The Captive Environment", (Stephen Spotte) John Wiley & Sons, 1979
"Protozoa in the Water Industry, (Biology in Focus)", (Colin R. Curds) Cambridge University Press, 1992
"Biology of Fresh Waters, (Tertiary Level Biology)", (Peter S. Maitland) Springer, 2nd Edition, 1990

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