

KHA Training Program

Filtration Module

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AUTHORS SYNOPSIS

This KHA training module must be read in conjunction with the AKCA Guide to Filters and pre-filters and with the KHA sections on Pond Design and the section on Water Quality.

Whilst “filtration” on koi ponds has become a somewhat controversial subject full of emotion, there are basic principles that apply to all variations hobbyists may encounter.

In this section, the terms ‘filters’ and ‘bioconverters’ will be used to describe the devices that remove solids and chemicals, respectively, from pond water. More complete definitions will be given later.

As a wide variety of filters and bioconverters are available to the hobbyist. Koi Health Advisors must look past advertising claims, past personal points of view and past complexity.

It is a fact that all filters and bioconverters work. The human element transgresses certain natural laws of limitations and the failure of the system results.

A bioconverter is not working and will not work in only two circumstances. 1) when it is new and 2) when it has been damaged or destroyed by chemical or medication treatments to the pond or a lack of oxygen. In all other circumstances the bioconverter is working to some degree or the other.

Bioconversion is a simple and natural process in nature. Nature “works” – it’s as simple as that. The number of living organisms that can be successfully accommodated in a limited volume of water (the pond) is determined by the amount of oxygen removed from the water and the amount of toxic waste products added to the water during the process of metabolism by all living organisms in the pond.

Our ponds are a limited volume of water. In order to successfully sustain, in a healthy condition, a large number of koi, we have to re-cycle the same water. The re-cycled water is re-conditioned by removing the unwanted substances such as carbon dioxide, solids and nitrogen waste products then adding in vital oxygen. This purified and rejuvenated water is returned to the pond as quickly as possible for the benefit of the fish and the bioconverter.

It is remarkable that all bioconverters and filters work. The filter system simply has to remove the excretion in the water faster than it is added. The filter must also remove organics such as algae faster than they are produced in the pond. We simply have to add oxygen at a faster rate than it is removed. The purified water must return to the

pond as fast as possible.

The Koi Health Advisor Filtration module/section does not promote a specific bioconverter or filter design idea. All filter concepts are discussed.

This Module is viewed as a dynamic lecture. New facts and ideas are continually emerging. As this information becomes available it will be incorporated into this module.

A perfect pond can be described as one in which the fish are alive and healthy for some time, the pond is truly clear and the pond does not leak. The rest is robust debate at the edge of the pond on how to achieve this.

Chris Neaves

CONTINUUM - Koi Ponds are remarkably similar to the human body - we compare these similarities in - The Comparative Introduction

A COMPARITIVE INTRODUCTION

The simplicity of filtration on a koi pond is remarkable. The pond, the piping, the filtration, the bioconverter and the returning water to the pond can be compared to the human body.

Our lungs introduce air into our systems and cells by making gaseous exchange possible. The oxygen allows chemical processes to occur in the cells. This activates our bodies. The liver is a filter removing toxins and impurities from the blood. The kidneys, colon and skin excrete harmful by-products to waste.

There is one golden thread that enables all the functions to work - circulation of fluids within the body. These fluids carry a host of vital substances from oxygen to white and red blood cells to hormones to carbon dioxide etc.

No matter how large and strong the heart is (or a pump on a pond) it is useless unless piping, in the form of veins and arteries, are free of

restrictions and open for the circulation of blood. The blood that carries nutrition and oxygen into the cells also carries waste products away. Within the blood, a host of cells circulate to assist with the immune system, the nutrition and the oxygenation of the body cells.

It is an effective circulation that ensures the success of the organism.

A failure of any one of several organs will result in the death of the organism. For example, liver failure will result in the body being unable to filter and remove impurities from the bloodstream. The body will then die. With kidney or bowel failure the same thing - impurities in the body will reach toxic levels within a remarkably short time and the organism will die. A healthy circulation system with strong heart, open veins, open arteries, is the key to health within the body. The same principles apply to our ponds.

The human body is approximately 70 - 80% water. Our ponds are water and fish are 80% water. The volume of water of the pond is the living environment of our fish. The pond water is piped (analogous to the blood vessels) to a pump (the heart) and through various filters (equated to the liver, kidneys etc. of the body) for purification and rejuvenation. The pond water is brought into contact with the atmosphere via waterfalls, streams, and/or venturis for gaseous exchange to take place - exactly like the lungs. Oxygen is dissolved into the water and unwanted gasses pass out of the water just like the lungs.

Failure of any one of these systems will result in the death of the pond. When the pond dies the fish will die.

The purpose of any filtration on a koi pond is to remove unwanted substances from the water - continuously and quickly.

Just as removing the sugar and the tea leaves from a cup of tea would need two different approaches, so too in a koi pond different approaches for different problems are needed.

Impurities that are dissolved in the water need chemical removal by bacteria (bioconversion) or with charcoal or zeolite. Impurities in the form of solids need mechanical removal.

A bioconverter is a remarkably simple concept. This involves providing enough space for naturally occurring bacteria to grow on. These beneficial bacteria do a vital job in nature and in the pond of chemically changing toxic fish waste to less toxic substances. It's as easy as that.

Fascinatingly the bioconverter is not only home to nitrifying bacteria but home to countless other varieties, many of which have not been identified yet. This incredible diversity of microscopic bacterial life plays a vital role in the success of your pond.

Piping that is clogged or piping that is too small or even piping with numerous bends will restrict and reduce the flow rate, no matter how

large the pump. These losses can be substantial to the point of compromising the design of the system.

Losses caused by restrictions in unhealthy veins and arteries in the body compromise the circulation and the health of the person. Exactly the same occurs in a pond.

Starting at the Beginning

Viewing the entire pond system with the piping, the pumps, the various aspects of the filter and the returns it is literally a circle. Where do we begin within the circle? After all, a circle has no starting point and no end. As water is the medium in which fish live we will begin with the water.

Before the fish can be introduced into a pond, before bacterial growth will occur, before there will be any life in the water it has to be activated. Nature activates water or the atmosphere for that matter, with a gas - oxygen. We therefore, have to introduce oxygen into the system as the starting point. Once oxygen is introduced into the water it must be circulated throughout every part of the system. Just as in the body, the oxygen in the blood supply is circulated to every cell and every organ. Should the oxygen supply be cut off from any part of the body for long enough, that area will die.

In order to introduce oxygen into the bloodstream or into the pond water, the water must flow - it must move. Once the water begins to move and there is a flow through the system, oxygen will be introduced into the water with the natural gas exchange of the atmosphere and the system will become active and live. The fish can then be introduced into the system. Once the fish are introduced they will be fed and once they feed, impurities will be excreted into the water. The combination of oxygen and excretion from the fish results in the growth of naturally occurring nitrifying bacteria. These bacteria will grow on all surfaces within the pond. There they begin their job of converting the fish impurities to less toxic substances. Bacteria take time to reach large enough numbers to convert all the ammonia to nitrite and, at a later stage, to nitrate.

It is as easy as that.

Ponds generate an enormous amount of pollution or unwanted material.

This enters the pond system in various forms. Algae accounts for much of the organic build up in a pond. Various other substances such as dust, debris, etc contribute to the build-up of unwanted substances in the pond

This organic matter ends up in the filter system and must be removed regularly to ensure a healthy environment. The maintenance of a pond

system is absolutely critical to the long-term health of the fish.

You would not consider trapping ten dogs in a closed courtyard and never ever cleaning it. The pollution these dogs would create in a short time would result in illness, stress and death. Exactly the same applies to fish in the pond.

If you, as Koi Health Advisors, understand the principles and look at the concept of ponds as a global concept, you will have much less difficulty in analysing problems that occur within systems.

CONTINUUM - Fish ponds are not static environments therefore, the dynamics of a fish pond are discussed next in - The Dynamics of a Fish Pond

DYNAMICS OF A FISH POND

Water is a very remarkable substance. The extraordinary properties of water have a direct bearing and influence on the daily existence of our fish. A fish's body is composed of more or less 80% water. So it is easy to envisage fish as a volume of water separated from a volume of water (the pond) by a thin membrane (the skin). The most insignificant changes in the pond environment will therefore, have a direct and almost instantaneous influence on the life of our fish.

Each and every one of these Influencing Factors, let's call them "Ifs," is dynamic. This is very important to remember when dealing with pond situations. Sometimes we can create problems that are not really there by viewing various parameters in isolation. During the course of a 24 hour day each IF (Influencing Factor) has a ***natural dynamic change***. These dynamic variations can be recorded and a daily pulse or oscillation can be observed. As the seasons change so do some of the parameters - the most obvious is temperature. A pond or water system has a natural bio-rhythm of life to which fish have adapted to during the course of their evolution.

At any point of time, during the day or year, a measurement of one or the other IF will possibly be different when compared to another measurement taken at a different time of the day or year. These fluctuations or dynamics should never be viewed in isolation. A single reading on a test kit will present only an incomplete view of what is

actually going on in your pond. Therefore, you may be panicking and trying to make adjustments for nothing.

Nitrifying Bacteria

The nitrifying bacteria found in the places we encourage them to grow i.e. the bioconverters or any wet surface in our koi ponds, move through a dynamic range of abilities.

As they grow in the bioconverters and on all the parts of the pond they become stronger. Their collective ability to convert ammonia to nitrite then nitrate increases as their populations increase, fuelled by an adequate food source and a good supply of oxygen.

As temperatures drop in the winter months (below about 50°F / 10°C), these bacteria do not die off but become dormant. In periods when their food supply is reduced they also become dormant. When koi populations are increased and / or the feed to the existing fish population is increased, the ammonia in the water increases and the bacteria population will increase provided sufficient surface area (usually in the bioconverter) is available.

As these factors vary, so do the nitrifying bacteria populations. The nitrifying bacteria are dynamic and ever adapting in the pond situation.

pH

In the morning, the pH will be low compared to a test done in the late afternoon. The buffering capacity of the water will play a major role in the fluctuation of pH during the course of a day. The pH you record may be unique to your pond. Don't be influenced by "perfect situations". It may be slightly alkaline with a pH of around 7.8 - 8.2. It may be that your particular pond has a pH range of 7.2 - 7.6. Or there may even be greater fluctuations. This is the natural, daily, pH cycle of your pond. I strongly advise against attempting to adjust the pH to a perceived perfect figure of say 7.2.

Measuring the pH in the late afternoon you will inevitably find it is on the high (alkaline) side. The addition of acid to pond water to lower the "high" pH can be disastrous at this point in time. The acid will lower the pH *and* so will the natural pond cycle during the night. The result could be - a pH crash.

Sudden substantial fluctuations in pH values will stress koi and possibly kill them. Fish do not tolerate sudden substantial changes in water quality very well. If they do not die, then the stress they suffer may become a contributing factor to lowered resistance and a possible disease infection. Measuring pH should be done in conjunction with measuring total alkalinity. The total alkalinity will give you an indication as to the buffering capacity of the water against pH variations.

The amount of algae (mostly free floating, single cell algae that makes

the pond water green) can have a dramatic effect on pH, pushing the pH to very high levels in the evening after a full day's photosynthesis. The opposite effect is observed by a lowering of the pH in the early morning.

Not only the koi but also the toxicity of ammonia as well as the bacteria in the filter are affected by pH. Should your water pH fluctuate through a narrow range, your water is well buffered. Should there be large fluctuations you may need to buffer the water a little. The pH should not rise much above 8.5 at its maximum reading.

Koi have adapted to survive in a pH range of 6.5 - 9. Providing the fluctuation within this pH range is not large and providing the pH change is not sudden.

Temperature

On most occasions temperature will be lowest in the morning just before sunrise and the highest at sunset. (Unless your pond is built on a nuclear waste dump, which generates its own heat). Temperature is influenced by the amount of sun, the intensity of the sun the pond receives and other factors such as the wind speed during the day or night. Evaporation cools the water. Generally speaking koi should not be subject to more than about a 5°C (9°F) sudden change in water temperature. Always adjust the temperature gradually when moving koi around. An upward movement is tolerated better than a downward movement in temperature. Most ponds have a 1° - 3°C (1.8° - 5.4° F) variation in temperature in a 24 hour day / night cycle. Koi are more affected by temperature variations at lower water temperatures. And you will notice koi are more affected by a sudden lowering of water temperature than a sudden raising of water temperature.

Certain areas in the country can experience a 10 - 15°C (18° - 27° F) atmospheric drop in temperature in a day accompanied by high winds. Ponds can and do drop temperature significantly in these circumstances. The koi suffer from stress and disease problems can occur later.

The koi can be helped through large, sudden water temperature changes by the addition of a good grade coarse salt at a rate of 1 - 2 kg per 1000 litres (or about .85 - 1.7 lbs per 100 gallons) immediately after the temperature has dropped.

Oxygen

Oxygen is possibly the single most important element in pond water - and a most neglected aspect of koi keeping. For life to exist in water there must be oxygen dissolved in it. The fish, the bio-filter, organic decomposition etc. all extract oxygen from the system. Oxygen is introduced into the water through gaseous exchange between the atmosphere and water molecules. Oxygen is introduced into the pond via

contact with the atmosphere through design considerations such as streams, waterfalls and apparatuses such as venturis and air blowers. High turnover rates will promote higher oxygen levels. Photosynthesis by algae during the day introduces additional oxygen, but removes it at night. Air under pressure through venturis can cause gas imbalances in the water and need careful consideration in their placement in the pond.

Oxygen levels can fluctuate dramatically during the day and night as well as during periods of high and low temperature. There can be significant oxygen variations in ponds with poor circulation or in ponds which do not move the water away from the bottom of the pond. i.e. the point furthest from the atmosphere. There is less oxygen in pond water at higher altitudes (6000 ft above sea level) - about 18 - 20% less than at the coast. There is continual competition in the pond for the limited amount of oxygen available at any given time. The fish, the plants, the micro organisms all need oxygen rich water - all the time. Algae and submerged plants have a dramatic influence on oxygen levels in a pond during a 24 hour day / night cycle. The photosynthesis process during sunlight may rocket oxygen levels to saturation point and beyond. However, a dramatic plunge in oxygen with the reversal of the photosynthesis process at night can spell disaster, even to the point of fish suffocating in ponds at dawn.

It has been found that if the oxygen levels are 25% below optimum levels first thing in the morning, growth rates are reduced. The turnover rate will have a direct bearing on oxygen levels as will the stocking densities of fish. The faster the turnover rate the more water will come into contact with the atmosphere and the more gaseous exchange will take place. The more fish in the pond, the less oxygen in the water, as they are all respiring all the time.

Higher temperatures in summer mean there is less oxygen that can be dissolved into the water. Higher temperatures result in faster metabolism, which in turn means that the less-available oxygen is extracted faster at the same time it is needed in greater quantities by the fish and other life forms.

A shortage of oxygen will be noticed by observing the koi collection first thing in the morning. If the koi are moving lethargically and hovering near the surface you may well have an oxygen deficiency. Oxygen shortages have been measured in ponds with fancy pumps and filters - but with a lack of exposing the water molecules to the atmosphere. A shortage of oxygen can also be observed by watching the respiration of the fish. If the fish are respiring heavily or "piping" they could be, 1. stressed, 2. have a gill problem, 3. the pond water could be low in oxygen or 4. the fish could be exhausted for some reason. (and what have you been doing during the night to exhaust yourself, my little Cynthia Sanke?)

Ammonia

The levels of ammonia *and* toxicity of ammonia are never constant. A few hours after feeding the ammonia level will rise as the nitrogen wastes of the fish are excreted. This can actually be measured. A measurement just before feeding should produce the lowest or no ammonia reading (if everything is working). However, an hour or two after feeding a high ammonia level will be recorded as the fish are now excreting their metabolic waste products. Interestingly, a corresponding drop in oxygen levels at this time has also been measured in ponds as the koi consume more oxygen for the metabolism of the food.

The higher the temperature the faster the metabolic rate and the quicker ammonia will be released into the surrounding water. However, there is another dynamic related to ammonia - the toxicity of ammonia (NH_3) is not constant during the course of a single day. Ammonia is found in two forms in the pond. The toxicity of ammonia is pH dependant. Ammonia changes from ammonia to ammonium (NH_4^+) as pH drops i.e. it becomes less toxic. As pH rises (naturally during the day) the ammonium (or a percentage of ammonia) converts back to toxic ammonia.

Whilst very high pH above 9 makes a higher percentage of ammonia more toxic and has certain negative effects on koi, low pH has other effects on the pond system. The bacteria in the filter are oxygen and pH dependent. The bacteria that inhabit the filter medium are affected by pH. The nitrifying bacteria that oxidise ammonia to nitrite have a optimum pH range of 7.8 - 8.5. The lower limit for reasonable growth for nitrifying bacteria is given as pH 7.0 - 7.6. While the upper limit is 9.4. Around pH 6.5 nitrifying bacteria cease to function.

So what now?

Into this *dynamic* pond system we introduce two critical factors - fish and man. How can our koi possibly survive in an environment that can become 100 - 200 times more alkaline / acidic, have a temperature change of more than 40°F (5°C), have oxygen levels that can drop and rise dramatically, and have a shifting ammonia / ammonium percentage in a single day? How can our fish possibly survive the bombardment of toxic chemicals that are added to the pond in the name of medications?

The average enthusiast does not have the money to spend on equipment to monitor the water continuously. How can he possibly monitor all these IF's (Influencing Factors) continuously, make daily adjustments, provide the perfect environment for his koi?

The answer is simple - if your koi are alive and healthy and growing well -

you are doing it right. Your koi are the best test kits you have. It may be a joke amongst koi collectors that when a new pond is built they always suggest placing a few "testers" into the new pond to "test" the water. A joke yes - but it is an excellent way of testing the water for your new arrivals and new pond system.

The ancestors of Koi, the common carp, have been living successfully in freshwater rivers for millions of years. There are ancient fossilised remains of the ancestors of carp. It is a scientific fact that whilst a pH of 7 - 7.5 is advocated as "ideal" for keeping koi. Koi will live comfortably in a pH range of 6.5 - 8.5. A temperature range of 22°C - 28°C (72°F to 82°F) is ideal for keeping koi. However, they winter well down to 10°C (50°F). And provided the temperature is not below 8°C (46°F) for too long a period of time, they suffer no adverse affects after winter. Some reports give the lower temperature limit for winter survival as 35°F. The critical factor is these fluctuations must be gradual. Actually the less the fluctuations or the more gradual the temperature fluctuations, the less stressful the environment.

Oxygen levels are maintained by circulating the water correctly in the pond and by bringing the water into contact with the atmosphere continuously. The faster the turn-over rate of the whole system, the better.

Ammonia levels can be controlled successfully by providing additional surface area for bacterial growth. This extra surface area is often referred to as the bio-filter or bioconverter. The high oxygen levels provided by high turn-over rates will activate the bacteria and the metabolism of the fish.

The natural immune systems and osmo-regulation of the fish's body is adapted over millions of years to counteract natural fluctuations in the water and attacks from the outside world. Provided the fluctuations are not too great or too sudden the fish has the ability to adjust and survive the daily, monthly and annual bio-rhythms of the pond.

CONTINUUM - In order to discuss filtration we must define what we are talking about - Chapter 1: Definitions

CHAPTER 1: DEFINITIONS



- as they relate to koi pond filtration

Ambient Ammonia

Ambient ammonia is the background level of ammonia in the pond water and will likely vary over the course of a day. [There can never be zero ammonia in the pond as the koi are excreting ammonia in the pond whilst the bioconverter is removing ammonia from the water]

Ammonia

Dissolved gas excretion of fish primarily through the gills, as a result of the metabolism of the body ammonotelic which means they discharge up to 70% of their nitrogenous waste via the gill lamellae.

Bioconverter

A bioconverter is a specialized or dedicated area of the pond system designed to provide the proper environment for large colonies of beneficial bacterial to grow. The nitrifying group of bacteria, the chemolithotrophs, as well as the organic consuming bacteria, the heterotrophs, grow in the bio-converter. In some literature these areas are referred to as biological filters or biofilters.

Chamber

An area or enclosure where media is housed or settlement takes place.

Chemical Filter

Zeolite and Activated Carbon are substances (or perhaps geological materials) that absorb and adsorb ammonia and other substances directly from the pond water.

Denitrifying Bacteria

Free-living bacteria that convert nitrates to gaseous nitrogen and nitrous oxide. These are anaerobic bacteria and their cellular respiration occurs in the absence of oxygen.

Filter

A physical process (i.e. one not reliant on chemicals or biological organisms) to remove solid particles from the water.

Filters in Parallel

When the water to the filter chambers is divided into two or more portions and each portion travels through only one of the filter chambers, the filter chambers are said to be in parallel.

Filters in Sequence (Series)

When the water moves from the first chamber or container to the second chamber to the third chamber etc., the filters are in sequence or series.

Flow Rate & Specific Flow Rate

Flow rate is the volume of water that flows past a given plane (or through a filter chamber of a given surface area) over a given length of time. Expressed in terms of volume/time. (e.g. Gallons Per Minute GPM).

Specific flow rate: the flow rate divided by the projected area across which the flow takes place and is given in: volume/time/area. If the specific length units of volume and area are the same, e.g., feet as in cubic feet and square feet, it can be an expression of velocity, but only if no media is involved (water only).

Foam Fractionator

Also termed foam floatation and protein skimming, this process removes organic matter (DOC) and fine solids from water.

A narrow device with a rising column of air bubbles and a descending volume of water. Used to remove DOC (dissolved organic carbon or scum) from the pond water.

Heterotrophic Bacteria

A species of bacteria that digest (intake) organic material to obtain their energy.

Hydraulic Load

The relationship of flow rate to the available media surface area - is called the **hydraulic load** on the media bed. The first objective of hydraulic load is to encourage the water to move through the filter bed evenly at all points of contact between the media and the water.

Mechanical Filter

Mechanical Filters will be referred to as filters. These are areas where suspended and settled solids are collected for removal from the pond system.

Media

Any substrate, which is used to either support living organisms (e.g. bioconversion) and / or any substrate to filter material from the water.

Nitrifying Bacteria

Bacterial species found in nature that oxidise ammonia to nitrite and then nitrate. These are chemolithotroph species of bacteria that live in an oxygen rich environment, utilize mostly inorganic (without carbon) compounds as their energy source, and require carbon dioxide (CO²) for their source of carbon.

Organics

Used to refer to any material that consists of live or dead cells, or carbon containing material that is capable of being broken down by biological means. A material containing carbon that is derived from a life form. Examples - algae, leaves, fish faeces.

Speed (of water flow)

See velocity

Suspended Solids

Suspended solids are the non-dissolved pollutants that remain suspended in the pond water. Examples of suspended solids are fine dust, pollen, dead algae and all fine solids and/or those solids near zero buoyancy.

Settled Solids

Settled solids are the non-dissolved pollutants that settle towards the bottom of whatever reservoir they are in. Examples of settled solids are heavier particles of dust, water logged organic material and leaves.

One of the prime pollutants, in terms of quantity, in pond water is dead algae. This accounts for as much as 60 - 70% of the organic material. However, in some lightly loaded ponds, it may be 90% of the organic material which clogs up the filter system.

Surface (Flow) Area (of filter chambers)

Cross-sectional area or **Projected area** (the area that would appear if you took a picture and projected it onto a screen) - this term is sometimes used in engineering.

The projected surface area of the media at right angles to the flow of water in the individual chamber(s) in the filter or bioconverter. Different from the surface area of the media.

Surface Area of Media

The total surface area of the media in the bioconverter and can vary greatly according to the type of material. Surface area of media relates to the area on which the bacteria may grow.

Velocity

The speed at which a fluid travels. In our case the speed at which the pond water travels through any part of the system.

The velocity or speed of the water is less in a bigger tank (given the same flow rate through the tank).

Vegetable Filter

An area in the pond system, usually away from the koi, where plants are encouraged to grow. The pond water is run through and over the plants and/or the plants' roots in this area (such as a stream bed).

UV Lights

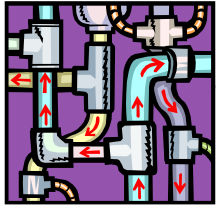
Ultra-Violet Lights are a type of light that has a specific band of wavelengths primarily used for controlling algae. Now referred to as Ultra-Violet sterilizers by many in the hobby.

Ozone

Tri-atomic form of oxygen.

CONTINUUM - The pond must be activated before life can exist and live in the water - we must move the water - Chapter 2: Flow Rates

CHAPTER 2: FLOW RATES



Flow Rate to and from Filters and Bioconverters

Flow rate is critical for all intensive aquaculture systems, as it determines the rate at which oxygen and other resources (e.g. calcium carbonate which will buffer a system's pH) are brought into the system, and also the rate at which excretory products such as faeces, carbon dioxide and ammonia are removed from the system.

Stocking densities and flow rates are intimately connected. In general, the higher the stocking density the faster the turnover rate should be.

Basic Principles

1. All the water should pass through the filter system. Any water by-passing the filter will dilute the effect and efficiency of the filter system.
2. The entire pond volume should pass through the filter system as quickly as is practical and returned to the fish, i.e. the turn-over rate of the pond volume should be high.
3. Once in the mechanical or settlement part of the filter, the water should slow down. Slow moving water encourages settlement. Flow rates of the entire system must be maintained. Increasing or decreasing the size of the filter chambers can adjust the slowing down or speeding up of the water flow in the filter system.
4. In the bioconverter part of the system, the water can flow fairly quickly as the conversion of ammonia to nitrite to nitrate takes place immediately on contact with the nitrifying bacteria. The flow rate must not be too quick or the water may flush the heterotrophic bacteria from the media.

Achieving and Maintaining Flow Rates

Basic Principles:

1. The heart of the system – the pump, activates flow rates.
2. It is critical that the pump run 24 hours a day.

3. Generally speaking the larger the pump the greater the flow rate.
4. Larger pumps cost more to run.
5. Different types of pumps will have different running costs as the pumps have electrical consumptions.

Moving Water Around

Basic Principles

1. Water is usually moved around the system and between various discrete sections of the system through piping.
2. Piping on a koi pond can be equated to the veins and arteries in the body.
3. Restricted piping will negatively affect flow rates and water delivery.
4. Various design features are used on ponds to collect the water and direct it in a specific direction.

Importance of flow rates

1. The pond water has to be moved from the pond to the bioconverter and the mechanical filter.
2. Bioconverters and filters can be some distance from the pond or they can be at the pond's edge. Some old-style designs are even IN the pond. The design considerations will dictate the placement.
3. The size and length of the pipe work in combination with the pump will dictate the flow rate irrespective of the size of the filters and bioconverters. Pipe work will alter the flow rate calculations because of frictional losses. Additions with restrictions, such as sand filters and venturis, will greatly reduce the flow rates.
4. In general, the faster the turnover rate of the whole system, the faster the impurities will be removed and the more oxygen will be dissolved into the water.
5. The faster the impurities such as ammonia are removed, the healthier the pond water will be. The faster the organic matter such as algae is removed the clearer the water will be.

Gravity Fed Pipes:

In order to maintain correct high rates throughout the entire system, an important point to consider is that far more water is pumped through

a given pipe under pressure than can be fed through the same pipe under gravity.

See KHA – Pond Design section by Burt Ballou

Design Features for Moving Water

Bottom Drains

A bottom drain is, as the name implies, an outlet or drain located usually at the lowest point in the pond or filter. These drains provide several functions: 1) to remove the heavy debris from the pond or filter, 2) to remove the bottom water (usually the least oxygenated water in the pond) 3) to provide circulation of the pond water by drawing the top and best oxygenated water toward the bottom.

In a pond, the bottom drains can feed water directly to the pump, they can feed water to a discharge box or settling chamber or they can be used to flush the bottom water directly to waste. In filter chambers they are used to flush the accumulated solids to waste.

Size of Bottom Drains

See KHA – Pond Design Section by Burt Ballou

Placement of Bottom Drains

The placement of bottom drains can have an effect on the circulation of the pond water and the efficient removal of impurities from the water.

For example, placing a bottom drain directly beneath a waterfall will result in purified water being drawn directly out of the pond instead of circulated and diluted around the pond.

If there is circulation the entire pond will have a vortex type action and settlement will take place in the centre of the pond. Placing the bottom drains together in the centre of the pond would result in the solids being drawn from the area where they settle.

See: Pond Construction Section for examples of bottom drain layouts

Pumps

Pumps are the heart of the pond. The heart pumps blood to each cell. The pump on a koi pond must pump the water from the pond, through the filtration system and return it to the pond.

Pump Capacities

See KHA – Pond Design section by Burt Ballou

Power consumption

See KHA – Pond Design section by Burt Ballou

Placement

See KHA – Pond Design section by Burt Ballou

Effects of Frictional Losses on Pump Outputs

No matter how powerful the pump, the final output will be restricted by several factors. Restrictions will reduce flow rates and ultimately affect the stocking density allowable in the pond.

Smaller diameter piping will reduce the flow. Longer lengths of piping will reduce the flow. Bends and elbows reduce the flow.

Using larger diameter piping will improve the flow rates.

Reducing the number of 90° bends will improve flow rate. A single 90° bend has the equivalent frictional loss of about 50ft of piping.

Claimed water delivery vs. actual water delivery of pumps

There is often a disparity between claimed flow rates and actual delivery of water of pumps. Different makes of pumps may have the same power motor driving them but often they deliver different amounts of water.

Flow Rates Through Bioconverters and Filters

Basic Principles

Oxygen must be introduced into the pond water before the fish can be introduced and before nitrifying bacteria will develop.

Water passing through the bioconverter chamber and media should not be so fast that conversion of impurities is minimal. Very fast flow rates through bioconverters can scrub off the bacteria growing on the media.

Conversely the flow rate should not be so slow that water that has been purified is sitting in the filter chamber taking up space that could be used more efficiently. It is remarkable that both fast and slow moving flow rates work to a degree. However, filters that flow too fast and filters that flow too slowly are *inefficient*.

Mature filters with large masses of nitrifying bacteria will be able to convert almost all ammonia to nitrite and nitrite to nitrate on a single pass through the filter medium. This should be the goal - small, cheap to run, easy to maintain and efficient.

The turnover rate of the whole pond should be as fast as possible, but

the flow rate through the filter/bioconverter system should be set so the solids can be removed and efficient nitrification can take place.

Effects of flow rates on ambient ammonia

The flow rate of the pond water through the filter chamber or chambers has a bearing on the levels of oxygen and ammonia in the system. This is a very important consideration because it directly effects the *ambient or daily background ammonia levels as well as oxygen levels* in your pond.

The fact is, the actual ammonia level in a fully recirculating pond can never be zero - even if the filter design is so efficient in design as to remove 100% of the ammonia, nitrites and nitrates that passes through it.

There will always be some quantity of ammonia in the pond water by virtue of the fact that the fish are continuously adding ammonia to the water. The filter can only remove ammonia from that portion of the pond water that is moving through it at any given time. However as one portion of the pond water has ammonia removed, the fish in the pond are polluting the balance.

The greater the fish load, the higher the ambient ammonia level will be (background ammonia). The filter design should also take this into account. The bioconverter should be designed in such a way that the water that is purified is returned as quickly to the pond as is practical.

From this explanation, it should be obvious that the greater the number of pond volumes moved through the filter each day, the lower the ambient (average daily background) ammonia level will be.

Flow Rates and Ambient Ammonia

Pond volume, bioconverter volume and flow rates are intimately connected.

In a properly designed system, the ambient ammonia level, while never actually zero, it is simply too low to be measured with most hobbyist test kits.

Low Ambient Ammonia

In order to ensure an acceptably low ambient ammonia level, the filter should be designed to process at least 12 pond turnovers per day. Thus, one-half of the pond's volume will be pumped through the bioconverter every hour. Increasing the turnover rate to one full pond volume per hour (24 turnovers per day) would be even better. However, a close examination of the costs for the larger pump and higher electricity running costs should be made.

To determine a rate of one-half pond turnover per hour, divide the volume of the entire system, the pond, the filter and the bioconverters volume by two. This will give you the flow rate entering and exiting the filter in gallons or litres per hour.

For example if a pond has a total capacity of 5000 gallons (19,000 litres), then at one-half turn over per hour we would need a pump that would be capable of pumping a minimum of 2500 gallons (9,500 litres) per hour, or 42 gallons (160 litres) per minute.

This would be the water actually delivered after various restrictions are taken into account.

Other Advantages of Higher/Faster Flow Rates:

1. It is an undisputed fact that koi have better growth, live longer and their colours are brighter and more intense in oxygen rich environments.
2. It is also an undisputed fact that biological filtration is more efficient and flourishes in a more oxygen rich environment.
3. Therefore, your pond system should include a method of aerating the water at ALL times to replace the lost oxygen. In other words, the pump must run continuously and provide a high turnover rate.

Dissolving Oxygen into The Water

The only way oxygen can dissolve in water is by contacting the water. This is typically accomplished by diffusion between molecules of water in contact with the oxygen in the atmosphere.

Some interesting deductions can be made from this fact. **a.** all the water's molecules should be brought into contact with the atmosphere at some time during a complete circulation cycle **b.** the water should ideally be brought into contact with the atmosphere as much as possible (*surface area and turnover rates*) to assist with the diffusion of oxygen into the water and the release of unwanted gasses into the atmosphere.

If the water was drawn exclusively from the surface of the pond and returned to its surface, the oxygen levels in the lower levels of the pond water may become critically low (unless supplemental circulation within the pond is provided like air stones). The water will take on a "dead" look. Anaerobic bacteria will flourish on the floor. The settled solids will decompose and produce the deadly Hydrogen Sulphide, gradually poisoning the system and fish.

Flow Rates and Removing Solids

Higher turnover rates through filters will remove solids at a faster

rate. In many cases this is the difference between murky water and clear water. However, if the water moves too fast in the settlement chamber nothing settles out.

If the turnover rate is faster or equals that of the production and accumulation of solids, then the water will clear.

Effects of fast and slow flow rates on mechanical filtration

See mechanical filtration

Pond Turnovers vs. Filter Flow Rates

Pond turnover = fast against bioconverters and filter flow rates = slow

What the difference is – how to achieve it in practice

CONTINUUM – Bioconverters and some (not settling chambers or vortexes) filters have materials in them that are referred to as media. The media performs different functions in filters and bioconverters. Media is the heart of the bioconverter. Chapter 3: Media

CHAPTER 3: MEDIA

Definitions

A media chamber is defined as a surrounding environment in which something functions or functions and thrives.

Media in a bioconverter is the substance in which and/or on which the organisms that perform the bioconversion live and thrive.

Basic Principles

1. Media can be used in the bioconverter or in the filter. The term media applies to both utilisations.
2. Used in a filter, the media is there primarily to provide some sort of barrier to the passing water. This barrier assists in the trapping of solids.
3. In a bioconverter the media is used to increase the available surface area for the bacteria that perform the function of nitrification to grow on. Media also traps "food" particles for the organic digesters to work on.
4. There are a host of bacteria growing in the bioconverter not only nitrifying bacteria but heterotrophs. All of these need space. Their living space must also be taken into account when designing a bioconverter

Types of Media

1. Stone - natural rock, gravel and sand must be inert & not affect the hardness of the water in any way. Occasionally other media such as marble chips, zeolite and oyster shells are used to intentionally increase the hardness and used as a media as well.
2. Ceramic - clay that has been fired at a very high temperature. It is sometimes porous. Available in various shapes such as spheres, stars and hollow cylinders.
3. Plastic beads - usually spherical shaped solid balls of plastic material.
4. Plastic shapes - plastic media is available in a wide variety of shape from extruded and cut shapes to injection moulded shapes. Plastic matting - random fibers of plastic thermally welded at points of contact.
5. Plastic foam - open cell polyurethane foam
6. Brushes - usually plastic bristles with stainless steel wound

centre wires.

The Bioconverter

The bacteria that colonise our bioconverters are unique in that they have to be attached to something. They are not free floating. This fact dictates that their food and oxygen must be brought to them. They cannot seek their own nourishment.

This leads us to reach other conclusions. The bacteria that grow on and inhabit the surface area provided in the bioconverter are microscopic. Therefore, the water laden with the food (ammonia) and the oxygen should come into contact with the microscopic layer of bacteria by not being too far away.

Another conclusion can be drawn from the fact that the bacteria adhere to the surface area is that the water passing by should move continuously. In other words the pump or pumps must run 24 hours a day to bring the necessary nourishment into contact with the bacteria.

As the water passes the bacterial colonies they oxidise the ammonia to nitrite in the presence of oxygen. Other species of bacteria oxidise the nitrite to nitrate, also using the oxygen in the passing water.

Bioconverters compete with the fish in the pond for the oxygen in the pond water to do their job of converting ammonia to less toxic substances. Bioconverters work better at high levels of oxygen. Koi are healthier at high levels of oxygen. Therefore, high levels of oxygen should be maintained through out the system.

The bioconverter virtually becomes a living entity after it matures. It is home to millions upon millions of bacteria and micro-organisms that are working in our favour by purifying the passing water. It is critical to keep this in mind as the filter may be damaged when we add chemicals to the pond water to treat the fish.

Nitrifying bacteria grow on the surface area of the media in the bioconverter but so do a host of other organisms. Including heterotrophic bacteria that consume organic matter.

Some studies indicate that the heterotrophic bacteria can, and often do, take up much more space than the nitrifying bacteria. So provision has to be made for all the life forms supported by the bioconverter.

Media

The material we use in the bioconverters to provide a surface area for bacterial growth is called the media. The media is the heart of your recycling system. The success or failure of the whole system is dependant, to a large extent on the media. (size, depth, type of material etc.)

A huge variety of materials can be used as bioconverter media. It is critical that the media must be inert and not affect the water quality in any negative way. Always be sure all materials are non-toxic and will not produce chemicals that will be harmful to the fish. And, it's a good idea to thoroughly wash the media before use in the filter.

Stone, gravel, plastic of any description, nylon hair curlers, pot scourers, shade cloth netting, etc. etc. can be used as media. Clay beads make excellent filter media material. Lava rock has many minute pores and a massive surface area for bacterial growth.

Lava rock in small, golf ball size pieces, makes an excellent bioconverter filter media. Large pieces of lava rock can also be used but it is difficult to clean w/o breaking off pieces of the rock. And large pieces of any media allow unwanted channelling. A sample of the lava rock to be used must be boiled before use to test if there are no chemicals such as sulphur in it.

Ceramic by-products that look like coral are emerging on the market. They are excellent filter materials but with similar shortcomings to lava rock.

A media with a rough surface makes a more hospitable place for bacterial colonies to establish themselves and additionally, has a larger surface area. Media with rougher surface areas can withstand rinsing with less damage to the bacterial biomass but also retains some detritus.

Plastic in various forms is extensively used as a media. Plastic is convenient and light to work with. One draw back is that it can be very expensive. Another is that the microscopic surface provided by plastic for nitrifying bacteria is often very smooth. Unless the bioconverter has an efficient up-stream settlement tank or mechanical filtration of some sort to remove the solids before the bioconverter media, it must be capable of dealing with the debris load. The hollow spaces in plastic rings make wonderful areas for accumulating waste solids.

Media Surface Area

The surface area of bio converter media is important. This is the total surface area available in the bio converter for bacterial species to grow on. Not only nitrifiers grow in the bioconverter but also a host of heterotrophs. The nitrifiers convert the ammonia to nitrite to nitrate and the heterotrophs consume the organics that become trapped in the filter media.

Obviously media with a rough surface would be more habitable for bacterial growth when compared to a smooth surface.

The total surface area for bacterial growth in a bioconverter is

increased (even if media with a small surface area is used) by increasing the volume of the media.

The volume can be increased in two ways. Firstly, by increasing the depth of the media. In this case, the flow through rate will remain the same. Or, increasing the size of the chamber through which the water is passing will spread the media out (keeping it shallow). The direct consequence of this is that the water flow rate past the bacteria will slow down.

Media with massive surface areas can mean smaller bioconverters can be built. However, smaller bioconverters will have very fast water flow rates. Therefore, a compromise must be found between massive surface areas of media (small bioconverters) and the very fast flow rates that will either scrub the bacteria off the media or remove their food supply before they can utilise it.

Hydraulic Loads on Media or Even Flow

Hydraulic load or even flow can be defined as the even movement, over the whole bioconverter chamber, of water on the interface between the media and the passing water. Once the water enters the bioconverter chambers it is essential that the water has an even flow through and past all the media. In other words the water passes evenly through the media with out channelling. Any channelling makes the bioconverter less efficient.

In open trickle filters the hydraulic load will be even as the water is sprayed over the top layer of media and it trickles evenly down as a thin layer of water through the filter media.

Up flow bioconverters must be designed in such a way as to ensure the water moves evenly upward through the media.

In up-flow bioconverters, a grid to suspend the media off the floor will ensure the hydraulic load is even. The open chamber underneath the media makes flushing easier.

Physical Lay-out of the Media

The way the media is packed inside a bioconverter chamber can have a significant influence on its efficiency. It is critical that little or no channelling takes place in the media. Any channelling will result in water by-passing a portion of the media and the bioconverter becoming less efficient.

Media beds with channelling could mean sections are deprived of oxygen rich water. Such areas may die and become anaerobic producing smelly and toxic hydrogen sulphide. Further, channelling will allow a portion of the pond water returning to the pond with the impurities it brought into

the filter chamber in the first place.

Effects on Flow Rate with Different Media in Different Chambers

Different media will have different flow rate characteristics. When packed, some media have smaller openings between the pieces. An open media will have less flow restrictions than one with smaller openings.

Chambers with different media can have a greater or lesser tendency to 'back up' or clog due to their different flow characteristics.

Depth of Filter Media

Whilst it is anticipated that deep filter beds will have less and less oxygen in the levels far from the inlet, there is much evidence that this phenomenon is insignificant in most instance.

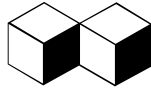
As ammonia and oxygen rich water passes media with nitrifying bacterial colonies growing on them, the ammonia will tend to be removed in the presence of the oxygen. Although this is done immediately on contact the bacteria do have a finite ability in this regard. Thus any residual ammonia flows on to the next colony and to the next, etc. Also any ammonia or oxygen not used by the bacteria simply passes on to the next part of the system.

When the bacteria in the lower areas of the bioconverter are saturated with ammonia their needs are minimal and the excess ammonia passes to the next portion. As soon as they need nutrition they begin the oxidation process again. This is an ongoing and dynamic process in the media bed and should not be viewed as an on - off type of situation.

One problem that is encountered with deep media beds is the build-up of organics and the subsequent difficulty in cleaning (see: Pond Design section for ideas on how to clean filters effectively) It is anticipated that filters will remove much of the solids in the pond water before the bio converter, however reality suggests that there will always be a small amount of solids passing into the bioconverter.

CONTINUUM - Koi Ponds produce vast amounts of organic material. Solids in the form of dust and pollution are continually added. Pond water needs to be cleared of these solids so the bioconverter can operate as efficiently as possible. Chapter 4: Filtration

CHAPTER 4: FILTRATION



Whilst bioconversion removes ammonia etc., there are various other forms of filtration – mechanical removal of solids, settlement, DOC removal. They have basic principles governing them.

Basic Principles

1. The purpose of filtration on a koi pond is to remove solids from the water. Removing various solids results in clear water. Clear water allows us to see our koi.
2. There are various methods of filtration. From settlement to vortex action to screening.
3. Generally speaking, slowing the water down through the filtration part of the system will assist with removal of solids. However in true vortices, water is sped up to assist with the elimination of solids.
4. Solids in water are in various forms. The most common in ponds is algae. All ponds will produce algae to a greater or lesser degree. Algae is organic material. When it is trapped in the filter or it dies and enters the filter, it will decompose. Decomposing algae (organic material) has a negative effect on water quality. It will remove some oxygen and it will add some ammonia.
5. Filtration is the high maintenance area of the pond. Filtration design should take this factor into account.
6. No matter how complex or how simple, the filter and settlement areas must be maintained regularly. This fact is critical for maintenance of water quality.
7. Filters are often attached to ponds before the bioconverter to ensure the water is as free of solids as possible. This is to prevent the bioconverter from clogging and becoming inefficient.

Mechanical Filters

All mechanical filters are used primarily for the entrapment of the various solids found in koi ponds. They can be incorporated almost anywhere in the filtration system.

Various types of mechanical filters -

1. Settling – debris heavier than water.
2. Settling aided by centrifugal and/or differential hydraulic forces
3. Mechanical exclusion – screens, fabrics, sand floating media other matrixes of small holes – physical straining.
4. Mechanical entrapment - (brushes, matting, floss, floating media, rocks, sponge, sand beds, stone beds etc)
5. Circular-flow – vortexes (not really vortexes but called that by the people who make them)

Types of Media used in Mechanical Filters

1. Stone - natural rock, gravel and sand.
2. Plastic – beads usually spherical shaped solid balls of plastic material.
3. Plastic foam – open cell polyurethane foam.
4. Plastic shapes - extruded and cut shapes, injection moulded shapes.
5. Plastic matting - random fibers of plastic thermally welded at points of contact.
6. Brushes - usually plastic bristles with stainless steel wound centre wires.
7. Screening – woven screen usually stainless steel or plastic.

Filters can be open or closed in design, i.e. closed are under pressure.

Open Mechanical Filters

Open mechanical filters can have the water gravity-fed through them and therefore, need specific design considerations for water levels. Open mechanical filters can also have the water pumped to them and forced through the chamber or chambers. This design can have the placement of the chambers almost anywhere (above pond water level) as the water will have gravity flow back to the pond. Sucking the water to the pump then pumping it to filters is less efficient at removing fine solids as the pump impeller creates more fines by macerating the solids.

Closed Mechanical Filters

Closed mechanical filters are dependent on water pumped from the pond through the container. Closed or pressurized filters can be almost placed anywhere.

1. Sand Filters (variations of pressurized or swimming pool sand filters) see sand filters.
2. Floating bead filters – (also used as mechanical filters).
3. True vortex filters – closed system with fast spinning water.
4. Cartridge filters – media is in cartridge form, is generally removed and hosed off for cleaning.
5. Bag filters – fine mesh bag – can be a long tapered 'sock' stuck into a large diameter pipe.

Settlement Out Side The Pond

Settling Chambers

Areas or containers outside the pond where the water is slowed down. For settling tanks to be effective, they need to be large so that the water passing through them is forced to slow down. Alternatively, they have to have some type of baffle arrangement to screen the passing water. In most cases, large chamber with baffles are used.

As the water slows down, the solids settle out. The larger the settling chamber the more the water will slow down. If the water could be brought to a complete standstill a very high percentage of the solids could be settled out. However, this would require settlement tanks larger than the pond its self. If space is at a premium other types of settling tank designs can be used.

Gravitational settling is a process by which solids denser than water eventually drift to the bottom of the chamber under force by gravity.

The settling tank is there to help slow down the rate of clogging of the pump and/or bioconverter. By placing the tank or basin so that the pond water flows through it before entering the biological filter, you can reduce - but not eliminate - the rate of clogging in the bioconverter itself.

Settling Basins and Discharge Boxes

See KHA – Pond Design section by Burt Ballou for more complete information on these design features.

It is critical that the discharge box, which is designed to collect solids before the pump and filter medium, have some method of easily flushing the solids to waste.

It makes no logical sense what-so-ever to collect solid waste in this area and then make it impossible to flush or clean! An outlet, directly to the storm water drain or garden should be installed in the discharge box. Valves or stand pipes to close off the pond and the filter boxes or

chambers are necessary. The discharge box or settlement tank should be totally isolated and thoroughly flushed when necessary as this is the area of the filter system which will require the most regular maintenance.

Organics that collect in any part of the pond system will bio-degrade and negatively affect water quality.

Sand Filters

Pressurized containers – sand filters – that are utilized on swimming pools are sometimes used on koi ponds for removing solids and also as bacterial bioconverter areas.

High rate sand filters are designed for use with chemically treated water. This point is important to remember. In a swimming pool, after chemicals have been used, the algae and micro organisms in the water die. This results in their cell structure collapsing. The collapsed cells take up less space. The chemicals poison the organics in the water so they take days or weeks before they start to grow again; therefore, the load on the filter is minimal. Under these circumstances a single sand filter will be adequate for the average swimming pool.

In our ponds the situation is totally different. Organic substances and micro organisms in the water are produced continually. Algae is a major source of solid organic pollution in the pond. Therefore, we have to change the parameters for the use of high rate sand filters on koi ponds from the way they are used on swimming pools.

The most important limiting factor of sand filters is that they are highly restrictive of flow rates. The fine sand or gravel in the bed and the limited surface area of the sand bed itself, as well as the size of the pump used limit the flow rate. The multiport valve that is standard equipment on such filters also restricts flow rates. The rapid build up of organics in the sand bed further restricts flow rates.

Taking the above into account, we have to "redesign" high rate sand filters for koi pond applications. It is critical to maintain flow rates in koi pond situations and sand filters need frequent back washing.

A single high rate filter works very well on a small pond but on large ponds they are effective only for a limited time. The larger the pond volume the quicker a single sand filter will clog up. This in turn means frequent maintenance by backwashing. Higher stocking densities in any pond make regular cleaning of the pond filter system essential.

Daily removal of solids can be overcome by having two or more sand filters IN PARALLEL.

With two or more sand filters in parallel, the water moves through several multiport valves (far less restriction) and then several sand

beds at the same time. The flow rate is greatly increased but the filters still do their job.

When the filters are back washed each filter must be backwashed separately. This gives maximum flushing capacity to each sand bed.

Sand filters are sometimes by-passed. If this is done for any longer than a day or so it is absolutely necessary to remember to back-wash the filter before it is used on the pond again. The water trapped in the chamber is cut off from the oxygen in the atmosphere. It will become anaerobic within a very short time. Large amounts of anaerobic bacteria are not healthy for the koi and should not be pumped to the pond. Anaerobic conditions can be detected by a very obnoxious smell.

Sand Filter Use Summary:

High rate sand filters are very efficient mechanical filters. Efficient mechanical filters trap solids in a convenient place. The more solids that are removed from the passing water the quicker any mechanical filter will clog up. But the result will be clear water but a filter that needs frequent cleaning.

Consideration must be given to using more than one sand filter on larger ponds. These must be in parallel so that the system will benefit from improved flow rates because the restrictions from a single sand bed and a single multiport valve and restrictions in the arms will be eliminated. This results in large surface areas of mechanical and biological filtration and extended time between backwashing.

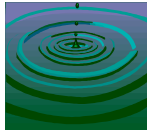
Bypassing sand filters for any length of time allows anaerobic bacteria to grow in the chamber. The filter must be flushed before being used on the pond.

Sand filters need high-pressure pumps. These are more expensive to run than other types of pumps.

The use of sand filters does not seem to allow the heterotrophic bacterial colonies to form properly (probably because of the frequency of backwashing) and thus a UV light is required to stop green water. Even the UV won't stop the string algae from forming – big filters will.

CONTINUUM - The liver (the heart is the pump see p. 7 of this doc.) of the koi pond is the bioconverter. Bioconverters are critical for the successful functioning of a koi pond. Chapter 5: Bioconverters

CHAPTER 5: BIOCONVERTERS



Basic Principles

While the function of the filter is to remove solids from the pond water, the function of a bioconverter is to utilise natural organisms such as bacteria to complete the nitrogen cycle by converting ammonia (symbol NH_3 - highly toxic to fish) to nitrite (symbol NO_2 , also toxic to the fish), to nitrate (symbol NO_3) not toxic to koi except at very high levels, to free nitrogen and nitrous oxide.

The excretion of koi is mostly ammonia via the gills and some solid faeces. This excretion is toxic to fish and has to be removed as quickly as possible. As the fish are excreting their bodies metabolic waste by-products throughout the day, the ammonia must be removed all the time by continuously running the pumps.

Ammonia is found in two forms in ponds, ionised and unionised forms. The higher the pH and temperature, the higher the percentage of the toxic or un-ionised fraction.

The ammonia gas dissolved into the water dissociates into ammonium, NH_4^+ (the + denotes it's an ion) and ammonia, NH_3 . This dissociation is something Mother Nature does based on the laws of physics and chemistry. How much is in each state is a function of temperature and pH (as far as we are concerned).

At a pH of 8 for example, and a temp of 20°C all the ammonia dissolved into the water dissociates into 98% ammonium and 2% ammonia.

As the nitrifying bacteria that grow in the bioconverter convert ammonium to nitrite to nitrate, the pond system is purified - if the filter is adequately sized and sufficient water is flowing through it.

Effects of High Levels of Ammonia

The amount of ammonia produced by the fish is approximately $0.03 \times$ feed. Therefore, for every 1000g (about 35 ounces) of feed that is fed, 30g (about 1 ounce) of total ammonia is produced. This is excreted by the fish primarily from the gills and to a lesser degree in the urine.

The ammonia production will vary throughout the day with the highest values occurring about two hours after feeding. However, this is temperature dependent.

High ammonia levels in the water mean that the fish cannot excrete the

ammonia from its body through the gills. The ammonia builds up in the blood, poisoning the fish. Fish can often be observed breathing much quicker or crowding round inlets (where the ammonia concentrations are less and oxygen concentrations highest) in an effort to get rid of the ammonia from their systems.

pH and Ammonia

An increase in the pH of a single unit increases the toxicity (amount un-ionized) by a factor of 10, regardless if the starting pH is 7 or 7.5 or 8 or whatever. It is essentially logarithmic in this regard over the temperature and pH regions we are involved with in koi ponds.

Bioconverters

The bioconverter virtually becomes a living entity after it matures. It is home to millions upon millions of bacteria and micro organisms that are working in our favour by purifying the passing water. It is critical to remember this, as we often do not realise that the bioconverter may be damaged under certain conditions. For example when we add chemicals to the pond water to treat the fish. Or when the pumps are turned off for any length of time.

The bioconverter is home to various bacteria species doing different functions to support their life forms.

Nitrifying Bacteria

Bacterial species found in nature that oxidise ammonia to nitrite and then nitrate. These are chemolithotroph species of bacteria that live in an oxygen rich environment, utilize mostly inorganic (without carbon) compounds as their energy source, and require carbon dioxide (CO₂) for their source of carbon.

The nitrifying bacteria that oxidise ammonia to nitrite have an optimum pH range of 7.8 - 8.8. The lower limit for reasonable growth for nitrifying bacteria is given as pH 7.0 - 7.6. While the upper limit is 9.4. Around pH 6.5 nitrifying bacteria cease to function.

Historically, Nitrosomonas & Nitrobacter are the names used for the bacteria suspected of converting ammonia to nitrite to nitrate in our bioconverters. Recent studies have produced evidence that these nitrifying bacteria are not present in bioconverters in large numbers. Nitrospira bacteria have been identified as being responsible for doing most of the converting of nitrite to nitrate. Work is currently underway to identify the bacteria, suspected to be a Nitrospira as well, which converts ammonia to nitrite.

A microbiologist in the 40's identified Nitrosomonas and Nitrobacter as two types of bacteria responsible for nitrification in soil and stated

that "probably the same were in the water environments". For the next 20 years or so, his original paper was continually referenced and new authors stated that "probably" it was Nitrosomonas and Nitrobacter. Then the reference and the terminology "probably" basically disappeared from the articles and it became a known "fact". This "fact" now seems to be being disproved.

Heterotrophic Bacteria

Heterotrophic bacteria are generally considered to be organic sludge degraders. An organism that is termed heterotrophic (e.g. heterotrophic bacteria) is one that gets its energy from the intake and digestion of organic substances.

All animals get their food this way, through the consumption of plants and other animals, however the term is more commonly used to distinguish between the different types of bacteria that are found in ponds and biological filters (bioconverters).

The heterotrophic bacteria are those that lower the BOD (biological oxygen demand) of the water by consuming the dissolved and particulate organics from the faeces of the fish (and algae as well as all other organics). These bacteria are distinguished from the nitrification bacteria that use the ammonia and nitrite for their energy source. (The heterotrophs require organic carbon; chemolithotrophs get their carbon from carbon dioxide).

Some heterotrophic bacteria are facultative anaerobes - meaning they can function with or without oxygen. They will do completely different functions depending on the level of dissolved oxygen present.

The heterotrophic bacteria appear when a food source is available (i.e. algae growth). They tend to disappear when the food source is consumed.

Under optimal growth conditions, nitrifying bacteria can double in population every hour or so. Heterotrophic bacteria, on the other hand, can reproduce in as little as 15 minutes to 1 hour.

Starting up Bioconverters

A new bioconverter, no matter how large or complex, is not functioning when it is started up or after a pond has been treated with certain chemicals. The various bacteria required to convert the impurities from the fish are simply not there. Some bacteria start growing immediately. But again, there are not sufficient numbers available.

This start-up period of a new pond can be very tricky. The water is in, the pumps are running, you have spent a great deal of money on new koi. The food is bought and the fish are fed. Immediately there will be a

build up of ammonia. Each time the koi are fed this level of ammonia will increase. Nothing is available in the pond / filter system that will remove this ammonia.

As ammonia is not only toxic to koi at high levels but it is also stressful to koi at very low levels, precautions must be taken in the start-up period of a pond.

Therefore, it is a good idea to shorten the start-up time of bioconverters.

Seeding Filters

One of the easiest methods of kick-starting a bioconverter is to seed the media with some media from another, reliable established bioconverter. Another method is to place some clean out from a good active bioconverter into the inlet of the new filter.

On each piece of media in a mature bioconverter will have literally millions of bacteria growing on it. By placing some of this media, even a few handfuls, in the new bioconverter media, this will seed the new filter.

By seeding the filter you will have placed colonies of the various types of nitrifying bacteria directly into the media. These will spread and multiply rapidly giving a rapid start-up of the bioconverter.

Open Bioconverters (Open media systems)

Bioconverters that are not sealed and operate under pressure are termed open bioconverters. These can be up-flow, down-flow or horizontal bioconverter are ones in which the water flows up-wards, downward or horizontally, respectively, through a material - the media - which is utilized primarily for the growth of nitrifying bacteria - and other beneficial bacteria.

Other types of open bioconverters

1. Integrated Vortex type

A vortex bioconverter is a container / area / locality / where, by the nature of its design, the water flows in a circular motion (usually before entering the media and at the bottom of the container) to settle solid matter to the centre for easy removal.

2. Trickle Filters

A trickle bioconverter is - a container / area / locality / where, by the nature of its design, the water flows openly (gravity fed) down-wards as a film over a media (a material which is utilized primarily for the growth of nitrifying and other beneficial bacteria).

3. Fluidized Bed Filters

Water flows upwards through the media and the velocity of the water pushes the media particles up into the container. This causes them to rise. As the water velocity increases, the particles rise higher in the column, expand and become more fluidised.

Fluidized Bed Filters usually have sand or small plastic particles for a media. This substrate allows bacteria to adhere to it and grow. The constant movement of water and particles in the chamber ensures that there are no dead spots. The velocity of the water is controlled so that as the particles collide, they do so with just enough force to knock off any excessive or dead bacterial floc.

Air can also sometimes be used to assist in the fluidising process, especially where water velocities are too low to obtain sufficient fluidising. The use of sand can be problematical. The weight of the sand makes it difficult to achieve an even bed fluidisation. However if the water flow stops, the sand packs down suffocating the bacteria rapidly. Plastic media are easier to fluidise.

7. In Pond Filters

Bioconverters and filters are occasionally incorporated inside the pond. Here a gravel or stone bed is used on the floor of the pond or in a section of the floor area.

A grid of pipes under the media bed is used to suck the water to the pump thus pulling the pond water through the filter.

These filters/bioconverters work in exactly the same way as other biological filter. However, as the media is at the bottom of the pond organics are drawn into the bed and clogging will be rapid. Once the bed becomes clogged, it has to be cleaned or it will become anaerobic and poison the entire pond.

The only way an in-pond filter can be cleaned properly is by draining the water and cleaning the media. Alternatively the whole media bed can be shovelled out and cleaned with pond water. Although many are still in use this makes in-pond filters impractical and possibly a danger to koi.

Closed bioconverters (close or pressurized systems)

The majority of the closed or pressurized bioconverters are sealed containers where, by the nature of its design, the water flows through media.

1. Floating bead bioconverter

A floating bead bioconverter is one in which the water enters the container at either the bottom or near the middle of the unit and rises

upward toward the exit. The bead media (usually plastic) floats in the top of the chamber. A biofilm forms on the floating beads. This film acts in two ways: 1) to nitrify the ammonia and 2) because of its 'sticky' nature, it tends to also act as a mechanical filter to trap solid debris.

2. Sinking media bioconverter

This group includes any chamber capable of being pressurized that contains media heavier than water thru which the water passes and is made less toxic by the function of the organisms living in and on the media. Examples of such bioconverters are: sand filters, sand filter housings with the media changed to one more open like balance and chambers with matting media like Japanese matting or Matala mat. Fluidized bed filters can also be operated in a pressurized chamber,

3. Combination bioconverters

Bioconverters that contain both sinking and floating media are found in some designs. In one commercial embodiment, sinking beads are used as a fluidised bed for bioconversion and the floating beads are used as a mechanical filter. One of the unusual things about this combination is that the water enters the bottom of the filter and passes through the bioconverter portion first. Because that bed is fluidised, no debris is collected there but rather it passes on thru to the second stage of the unit where the floating beads trap the solids.

Bioconverter and Filter Size

The conversion of ammonia to nitrite to nitrate is performed by microscopic bacteria that grow on all the surfaces in the pond system. However, they are concentrated in the bioconverter. This is the area designed to provide a large surface area for them.

The conversion of ammonia to nitrite to nitrate occurs instantaneously on contact with the nitrifying bacteria. If the ammonia molecule is some microscopic distance away from the bacteria, no conversion will take place.

Key factors dictating bioconverter size

As the ammonia load increases, more bacteria are needed not more time for conversion. Flow rates are directly related to this. Therefore, the amount of functional surface area available to the nitrifying bacteria is of importance.

Certain media have enormous surface areas but their full potential cannot be realised as the greater the specific surface area, the less the volume of media required. The less media utilised the smaller the media chamber. The smaller the media chamber the faster the water will move

past the media.

Very high velocities of water can remove the nitrifying bacteria from the media. Consider the flow rate through a pressurized bioconverter compared to that of a typical up or down flow bioconverter. Even during backwashing, nitrifying bacteria are not significantly removed although the heterotrophs and their food supplies (organics) are.

Surface Area – Projected and Total

Projected or Cross-sectional Area of the Individual Chambers

Individual chamber projected or cross-sectional surface area (of a square or rectangular chamber) is the length x the breadth of that chamber for up or down flow conditions.

Projected or Cross-sectional Area of the Complete Bioconverter

The projected or cross-sectional surface area of the bioconverter is the combined projected surface area of all the individual chambers. Each chamber should have a flow rate through it that is properly determined by its surface area. For a given throughput, the smaller the projected area of the chambers, the faster the water will flow and conversely, the larger the projected area, the slower the water will flow. The specific flow is the flow rate per unit of projected surface area.

Total Area of the filter material or media

The surface area of different media can vary greatly. Some ceramics advertise a phenomenal $10,000 \text{ m}^2/\text{m}^3$. Aquarium gravel has around $700 \text{ m}^2/\text{m}^3$. Plastics have between 100 and $1500 \text{ m}^2/\text{m}^3$.

Whilst very large surface areas may be attractive, the flow rate through the whole filter system and contact time must still be considered important.

Effects of different media on flow rates

Different media pack differently in filter chambers. The shape and the size have a direct influence on the flow through the chamber.

Having chambers with different void spaces can lead to problems. If the water is pushed through a multi chambered filter system and the second chamber has less void space than the first, back-up and overflowing will be experienced in the first chamber.

If the pump is sucking at the end of a multi chambered system and chambers with different media are used then the chamber with the least void space may be pulled dry.

Contact Time within the Bioconverter

Nitrifying bacteria convert ammonia to nitrite to nitrate virtually instantaneously. The flow rate through the bioconverter is usually slowed down in an attempt to get 100% conversion in one pass through the media by having ALL the water come in contact with the media in a single pass.

The flow rate through the whole pond system should be relatively fast. The flow rate through the bioconverter should be slowed down without affecting the overall flow rates. Increasing the size or number of the filter chambers in the system and running multiple chambers in parallel achieve this.

It is generally agreed that faster flow rates through bioconverters are more beneficial than slow flow rates.

Shutting Down Filters

Generally speaking it has been thought that shutting down filters for even a short time is detrimental to the nitrifying bacteria. However, there is some evidence this is not the case, provided the media is kept damp if the chamber is drained or provided the water around the media does not become devoid of oxygen if the water is kept in the chamber or chambers.

Nitrifiers are very patient - when the situation changes to something they don't like, they generate a lot of EPS (exo-polymer substances) for protection and go into a kind of hibernation waiting for the conditions to change for the better. They can wait a long time.

DAMAGING BIOCONVERTERS

Bioconverters are living entities and can be damaged. The addition of chemicals to the pond water often damages the biomass in the filter. Some chemicals do more damage than others. Antibiotics will not only kill bacteria in the pond but will kill the bacteria in the bioconverter as well.

The pH of the water affects the nitrifying bacteria. Pond water pH should be between about 7.0 and about 8.5.

The ammonia given off by the fish is processed into the much less toxic nitrate (passing from ammonium to nitrite to nitrate). However, while processing the fish waste, the filter produces acid that tends to lower the pH of the system.

If the pH drops precipitously below about 6.8, the bacteria stop working and the waste ammonia is unprocessed - this is known as a 'filter crash.'

If the problem isn't fixed and fixed correctly, the fish will die.

To prevent filter crashes, keep the alkalinity up so the water is

buffered against the acid that the bioconverter bacteria constantly produce.

CONTINUUM - Koi Ponds produce vast amounts of organic material. Solids in the form of dust and pollution are continually added. These substances are removed from the pond water in the filters. The filters have to be cleaned regularly or the passing water will come into contact with the decomposing organic matter trapped in this area.. Chapter 6: Maintaining Bioconverters and Filters

CHAPTER 6: MAINTAINING BIOCONVERTERS AND FILTERS



Basic Principles

Having a water feature means accepting responsibility. Our responsibility is to keep the water in the feature healthy. If we neglect the pond, the koi will suffer and we will also suffer. The pond, bioconverter and filter system **has to be cleaned regularly** - let's make it easy to do!

No matter how sophisticated a system is or how expensive it is, the reality is that if it is not properly maintained, the system will degenerate to the point where the fish will die.

Design good mechanical filtration so that the bioconverter bed is seldom disturbed. The longer the bed remains undisturbed the greater the biomass that will grow. This in turn means the converter will be more efficient at processing the impurities that flow through it. However, reality dictates that no matter how efficient the mechanical filtration is, the bioconverter will still need cleaning from time to time.

Mechanical filtration will always require more attention than the

biological filtration. Therefore, the mechanical filter must be as easily accessible and designed for ease in maintenance.

Bottom drains are sometimes designed to flush bottom water to waste only. Therefore, stand pipes must be drawn regularly to avoid the water trapped in the bottom drain from becoming anaerobic. In this case it is better to connect the bottom drains directly to the pump (although it is not always recommended) or directly to a discharge box so that the water is drawn continuously through the piping.

Cleaning Ponds & Filters

Maintenance

Lack of maintenance – the root of all evil?

One of the major causes of fish disease problems is lack of pond maintenance by pond keepers. Nature is working 24 hours a day, every day of the year. Algae (organic material) constitutes the bulk of the solid build-up in pond systems. This organic material will decompose. If it is allowed to build up, it may be cut off from the passing water and become anaerobic. Anaerobic bacteria produce hydrogen sulphide – this is toxic to fish.

Run your hand over a tabletop in the house for example, and every day there is a film of dust. Exactly the same continuous pollution, in various forms, is settling onto and into our ponds. Ponds are literally giant settlement chambers.

Backwashing Bioconverters and Filters

The pond keeper has to familiarize himself with the maintenance side of the system components. Many problems in water quality can be ascribed to poor maintenance (and often poor design which makes maintenance difficult). Each pond will be slightly different with regards to what needs to be done to keep the water pure and clear.

It is absolutely essential to make provision to have some method of cleaning pond filters - easily and thoroughly. Bioconverters should be cleaned less frequently. The use of pond water to avoid damaging the biomass with chemicals often found in tap water is recommended.

Primary Design Features for Successfully Cleaning Filters

It is a fact of life that ***all*** pond filters will clog to some degree at some time or other. Therefore, design the filter to be easy to maintain - when the need arises.

For more details see KHA – Pond Design section by Burt Ballou

Cleaning and Damage

Biological filter media that is removed can be kept moist at all times with pond water. This will keep the bacteria active. When washing filter media try to use pond water. This will avoid damage to the bacteria from chemicals in tap water.

The debate on the damage to the filter bed if it is turned over a few times a year to rinse away the excess solids is often exaggerated. The results of having the filter bed clear of organic and solid material far outweighs the damage done by the occasional washing it requires.

Most of the bacteria washed away will be the excess and/or dead bacteria. Provided the filter media is kept moist whilst back washing and turning, the damage is minimal. The bacteria being established in vast numbers in the filter bed will spread through the entire filter bed very rapidly once the system is started up again.

The secret is to use pond water if possible, and not tap water. Tap water contains chlorine and other additives that will kill many bacteria it comes into contact with.

How Often Should Filters be Cleaned?

As often as is necessary to maintain good clear water quality. Your personal circumstances will dictate the frequency of cleaning the filter.

The more frequently solids are removed from the mechanical part of the filtration system, the clearer and more healthy the water will become.

The less frequently the biological converter is cleaned or disturbed, the stronger the biomass will become. (This statement is subject to the bioconverter being free of solids).

Although these two statements are generalities and seem to contradict each other, it is a fact that by regular cleaning and flushing the chambers and media the fish will be healthier over a longer period of time.

Water Changes (water changes out)

Irrespective of the size and complexity of the pond filtration system we cannot escape the fact that we have to add fresh water from time to time to our ponds. The mere fact that there is some degree of evaporation and also water loss when cleaning the filters makes it necessary to top up the pond.

Water changes should be done regularly in ponds as the environment is always deteriorating to some degree - no matter how large or complex the filter system is. Many enthusiasts advocate a 10% water change per

week. The author considers this to be a minimum.

Regular water changes have advantages:

- various by-products of the pond system such as nitrate and phosphate build-up, DOC concentrations, pheromone levels etc. will be diluted.
- solids (suspended and dissolved) will be removed.
- essential trace elements and minerals will be replaced.

Fresh Water Caution

Tap water usually has chemicals added to it. Chlorine and chloramines can be deadly to koi. These chemicals can burn the gills of koi and suffocation may result.

Well or borehole water usually does not contain any oxygen and placing koi directly into fresh well or borehole water can result in severe stress and even death.

See: Water Quality section by Norm Meck for details and solutions.

CONTINUUM - There are many methods of removing ammonia we discuss some of them in. Chapter 7: Alternative Methods of Filtration and Bioconversion

CHAPTER 7: ALTERNATIVE METHODS OF FILTRATION AND BIOCONVERSION



Ion Exchange - Zeolite

The most commonly found ion exchange medium in aquaculture is zeolite material. Zeolite has positive ions held within a silicate lattice. The ammonia and other negative ions in fish waste water are taken up by the zeolite and bound into its structure.

Flushing with solutions such as sodium chloride or sodium hydroxide can then recharge the zeolite. Zeolites can maintain a high level of effectiveness if recharged correctly.

Zeolite is a unique substance. There are over 40 natural zeolites and 150 artificially made ones. Zeolite is literally a sieve on a molecular or atomic scale. Zeolite can be used to remove ammonia directly from the water, or as a biological filter medium. Zeolite can reduce water hardness. Zeolite can buffer soft water. Zeolite can remove certain heavy metals from the water. Another property is its ability to remove odours from the water. Indoor koi ponds can have a "fishy" smell. Adding zeolite to the filter will eliminate these odours. Zeolite can be used in ponds as ion-exchange medium for ammonia removal. Zeolite also varies considerably in its adsorption capacity. In order to use zeolite for ammonia removal, pond water must be pumped through the zeolite medium at least once every two to three hours that is the same for biologic removal.

For effective ion exchange by zeolite, continuous and extensive mechanical filtration is necessary.

Caution must be exercised when using zeolite in the system and salt is added. Salt is used to re-charge zeolite and adding salt to a system with zeolite can result in ammonia being released back into the pond and poisoning the koi.

Activated carbon

Usually used in granule form. Removes negative ions such as ozone, chlorine and fluorides from the water. Heating to 900°C can recharge it. Very useful when used to filter mains water where chlorine and other chemicals have been added to the water. It can be expensive and only certain types of activated carbon remove ammonia and chloramines.

Water Changes (water changes out)

See page 47

UV Lights

UV or Ultra-Violet Lights are a type of light that has a specific band of wavelengths primarily used for controlling algae. The bulbs used in ultra violet systems are designed to produce a light of a specific wavelength (around 254 nanometers). This frequency has a maximum take up of the light by the DNA in the living organisms.

Ultra Violet (or UV) light has been used for disinfecting water since about 1910. The effectiveness of the light depends on a number of factors including bulb wattage, age, turbidity of the water, cleanliness, the distance between the bulb and the organism, what the organism are, as well as the duration and intensity of light that the organism is exposed to.

The way UV works is similar to the things that happen when we sit out in the sun. The UV light kills off the DNA in the cells causing them to die

As a rough guide water borne algae and bacteria require a dose rate of 15,000 - 30,000 mW-sec/cm², whereas protozoa require doses in the region of 45,000 mW-sec/cm².

Disinfection rates differ in various papers and there is much conflicting information. Methods used in the laboratory are often very different from those in commercial aquaculture.

A UV light will only affect those organisms passing near it. It will not have any effect on those organisms in the pond itself.

Vegetable (plant) Filters

Plants in streams and in filter chambers can be utilised to remove certain substances from the water. Although plants do not remove ammonia from the water they do remove some nitrite and nitrate. The roots of plants that dangle in the water, such as water hyacinth, can hold large colonies of both nitrifying and heterotrophic bacteria.

Any planted area must be continually maintained to prevent the root system clogging up and cutting off the passing water from lower regions. These regions will become anaerobic and poison the system

Streams as Filters

Streams can be used as biological filters. The bed of a stream can be laid with gravel or stone. As the water passes over this bed nitrifying bacteria will grow.

Streams as filters must be shallow to prevent anaerobic bacteria

forming in the lower regions of the gravel bed. The gravel or stone bed will be a wonderful trap for organic material. In other words this bed can clog up easily over time.

Cleaning the stream regularly of organic material is critical to its success.

Foam Fractionation

Some times called foam floatation and protein skimming

This is a process that removes organic matter and fine solids from water in the form of a foam that is generated in a device.

A foam fractionator consists of three parts, a vessel (usually a column) through which the water flows either up or down, a bubble source (such as a diffuser or venturi) and a foam collection point. Foam fractionators do not work nearly as well in fresh water as in marine environments. Fresh water implementations are much more difficult to control.

The particulates that foam fractionation removes from the water are known as surfactants, and are comprised mainly of organic compounds (proteins). These compounds have one end that is attracted to water molecules (polar) and one end that repels water molecules (dipolar). As the bubbles rise through the column, the molecules collect around the bubble surface with the dipolar ends in contact with the air and the polar ends pointing out into the water. The molecules are therefore adsorbed into the surface of the bubble. Once the bubbles reach the water surface, the particles in the bubble surface prevent it from bursting and as more bubbles collect behind it, foam is formed.

This foam rises steadily out of the water as more and more bubbles build up behind. The diameter of the column is gradually restricted at the foam outlet, which increases the velocity of the foam, it is then fed away from the column and sent to waste. The increase in velocity is important as it reduces the amount of time that the bubbles have to stay in tact for, before they are removed from the column. The amount of foam produced is a result of the air flow rate, the amount of surfactants in the water, and the time taken for the foam to be removed.

Foam fractionators are often used in recirculating systems to remove some of the fine solids and reduce the loading on biological filters.

Foam fractionation can be observed on a daily basis in the pond. Ponds with high organic loads or changing water quality often have a foam developing at the base of a water fall - where the air bubbles attract the DOC or dissolved organic carbons.

CONTINUUM - Koi Ponds are often treated for parasites and diseases. This practice is dangerous and we discuss why in Chapter 8: Effects of Chemicals and Medications on Filtration ...

CHAPTER 8: EFFECTS OF CHEMICALS & MEDICATIONS ON FILTERS



Effects of Various Chemicals and Medications on Filters

Koi Health Advisors should perhaps understand that there is no such thing as koi medications. The vast majority of the substances we administer to the koi and the vast majority of substances we add to the pond water are poisons administered in limited dosages. These are radical perceptions, yes, however virtually any medication or chemical will disrupt the biological action in the bioconverter and may even kill the koi if the dosage is high enough.

A simple mistake of having the decimal point a single digit in the wrong place will increase the dosage by 10 times the recommended amount. The wrong calculation of the pond volume can result in the dosage being completely wrong and disaster will follow.

Different medications and different chemicals will disrupt the functioning of the bioconverter to a greater or lesser degree - depending on the type of chemical used and the dosage at which it is administered.

Any substance that kills bacteria will very likely be harmful to the bacteria in the bioconverters. This would include antibiotics and oxidizing agents, e.g., tetracycline and potassium permanganate.

CONTINUUM - We need to develop an ability to analyse problems in Koi Ponds. Therefore we conclude with. Chapter 9: Developing and Eye for Problems Associated with Filtration

CHAPTER 9: DEVELOPING AN EYE FOR PROBLEMS ASSOCIATED WITH FILTRATION



Message to Koi Health Advisors.

This part of the filtration module could have become a book on its own. However we have decided to take a different path by using this section to build a reference section together. Actually the case histories we deal with as a group during the duration of this course will be discussed and resolutions sought. Once we have solved the problem we can publish the data as a case number without becoming personal. We will cross reference cases for easy access.

In this way candidates will write this section together, based on their experiences.

I believe this will be more practical and useful to candidates on the present course and in the future.

Chris Neaves

We will start with two real life case studies to get the ball rolling:

Case #1

History

A moderately experienced but enthusiastic hobbyist set up a quarantine tank using a 500 gallon PVC show tank, a 35 gallon plastic trash can with OC foam as a prefilter/bioconverter combo and a 65 gallon plastic barrel with OC foam as a bioconverter. The units were joined in series.

The hobbyist overloaded the tank and did not watch the water parameters closely. Eventually and upon observing distressed fish in the tank, the hobbyist tested for ammonia and found very high levels. At this point the hobbyist emptied 50% water from the tank and refilled the tank from his pond believing that the 'aged' water would be better for the distressed fish.

The Problem

The fish went immediately into worse distress with one fish expiring before the hobbyist realized what was happening.

Testing later showed the pond water was at a pH of over 8 with a T.A. of about 150 ppm while the tank was somewhere below 6 with very little T.A.

Questions - Case #1

What went wrong with 'the fix' and what should the hobbyist have done and in what sequence?

Analysis & Solutions

Case #2

History

A koi enthusiast has a pond of 13200 gallons. He has 55 large koi of high quality ranging from 19 inches to 31 inches in size. Several are show winners. He has a sophisticated filtration system with 4 vortex tanks in sequence. The bottom drains bring the water into the first tank. The vortex action settles out much of the solids. The water then passes to the next tank that has Japanese matting as a biological medium. This is

repeated in the third and fourth tank.

The water is drawn off the fourth vortex tank by a swimming pool pump with a capacity of 6000 gallons per hour. The water is then pumped through a single 30 inch sand filter to polish the water and is returned to the pond via three inlets situated 12 inches below the water line.

The Problem - Case # 2

The fish are sluggish and are reluctant to feed. Some are degenerating in colour. One or two lie continuously on the bottom

Questions - Case # 2

What is the problem or possible problems and how can they be rectified?

Analysis & Solutions - Case # 2

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