

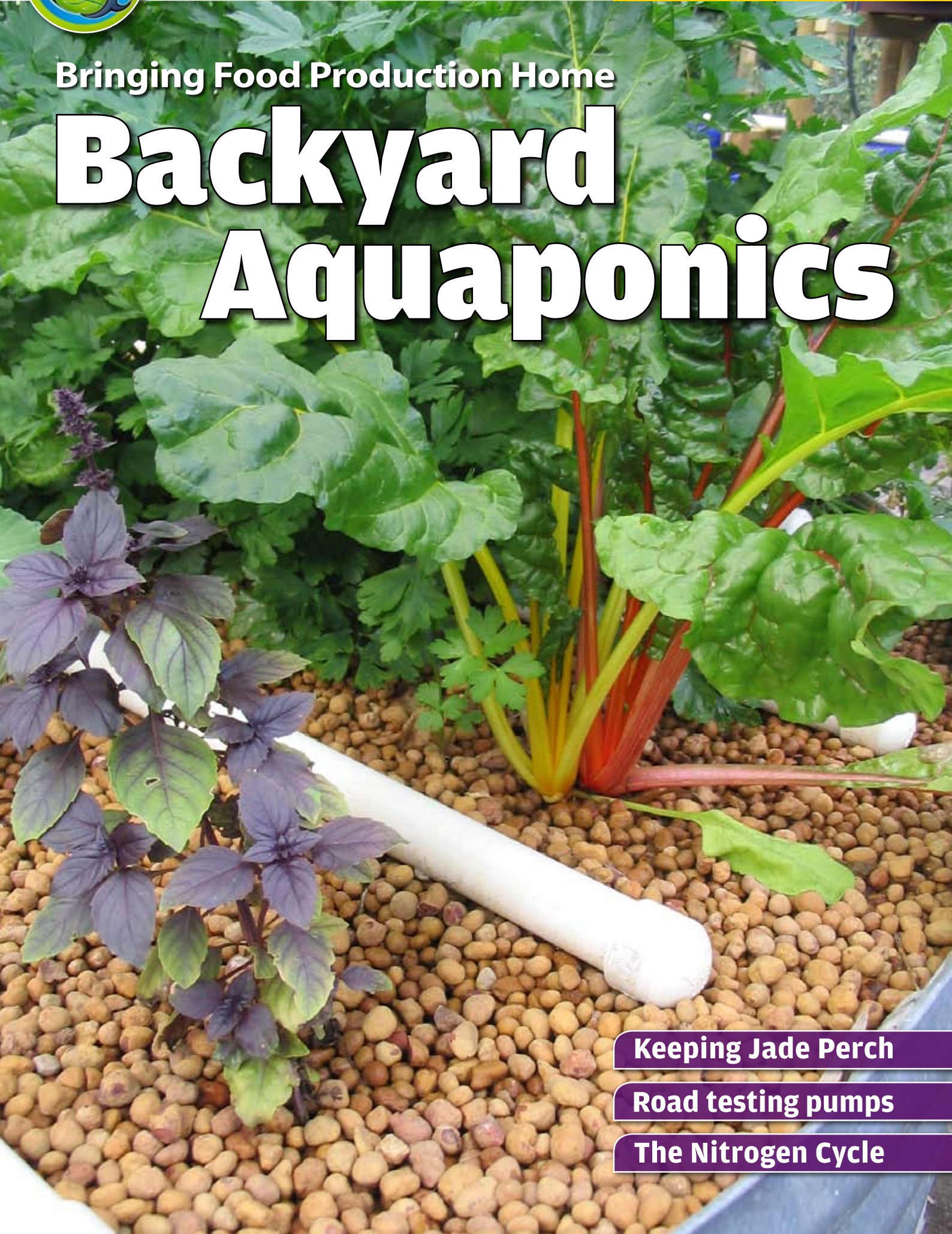


The No.1 Aquaponics magazine for the backyard enthusiast.

Issue 1 • **Summer** 2007

Bringing Food Production Home

Backyard Aquaponics



Keeping Jade Perch

Road testing pumps

The Nitrogen Cycle

Welcome

Welcome to the very first edition of the *Backyard Aquaponics Magazine*. 2006 and 2007 have been big years for aquaponics, especially in Australia. The Backyard Aquaponics discussion forum was formed in March 2006, and in the first 18 months, it's grown to become the biggest and best aquaponics forum in the world. With over 1000 members and more joining every day, there's new information and pictures being posted daily. The excitement generated by the discussions and photographs posted on the group is apparent by the number of contributions, over 90,000 posts in such a short time is astounding. Most states in Australia have been having group get-togethers for members to meet and discuss aquaponics first hand with each other.

The object of the discussion forum was to create a central learning hub, where people from around the world can learn from others in a stimulating environment. The online discussions have led to many new systems being built by members, with people sharing their knowledge and helping others with their design plans and problems. Members have been setting up systems all over the world in all types of conditions, from icy Alaska to tropical and desert areas of the United States and Australia; it's a testament to people's ingenuity the way that they have dealt with some of their difficult conditions.

I'd like to pass on my thanks to everyone who has been participating in the group. It's only through having a diverse group of people with varied skills and knowledge that such a melting pot of

ideas can be so highly productive. The forum has exceeded my wildest expectations and become a friendly thriving community that is helping to advance aquaponic knowledge, and make it accessible to everyone.

But, back to the magazine. This magazine will become a further extension of the discussion group, an information source where ideas, plans and information are laid out clearly for everyone to understand.

Where systems will be featured in detail, fish species documented, and problems discussed, it will be all things "aquaponic". Like the discussion board, the magazine will rely heavily on input from many different people.

Members have been setting up systems all over the world in all types of conditions, from icy Alaska to tropical and desert areas of the United States and Australia

We will also be drawing on other sources of aquaponics information from around the world to try and bring a truly international flavor to the information provided here.

If you have an idea for a story, or you'd like to offer some suggestions, please feel free to write to one of the magazine staff, we're here to help create something that's useful to everyone and we value your input. Thanks again, I hope that you find this first issue of the *Backyard Aquaponics Magazine* interesting and of value. ●

Joel Malcolm



Backyard Aquaponics

Issue 1 • Summer 2007

Backyard Aquaponics Magazine is a quarterly publication which aims to promote the ideas of Aquaponics and home food production coupled with healthy and sustainable living.

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What is Aquaponics?

By Joel Malcolm



A small healthy growbed with a large fish tank off to the side

Aquaponics is essentially the combination of Aquaculture and Hydroponics. Both aquaculture and hydroponics have some downsides, hydroponics requires expensive nutrients to feed the plants, and also requires periodic flushing of the systems which can lead to waste disposal issues. Re-circulating aquaculture needs to have excess nutrients removed from the system, normally this means that a percentage of the water is removed, generally on a daily basis. This nutrient rich water then needs to be disposed of and replaced with clean fresh water.

While re-circulating aquaculture and hydroponics are both very efficient

methods of producing fish and vegetables, when we look at combining the two, these negative aspects are turned into positives. The positive aspects

of both aquaculture and hydroponics are retained and the negative aspects no longer exist. Aquaponics can be as simple or as complex as you'd like to make it, the simple system pictured above has a large fish tank in the left of the picture, and a growbed filled with gravel raised above the level of the fish tank in the centre of the picture.

“research has shown that an aquaponic system uses about 1/10th of the water used to grow vegetables in the ground.”

Water is pumped up from the fish tank into the gravel filled growbed. The water trickles down through the gravel, past the roots of the plants before draining back into the fish tank. The plants extract the

of both aquaculture and hydroponics are retained and the negative aspects no longer exist. Aquaponics can be as simple or as complex as you'd like to make it, the simple system pictured above has a large fish tank in the left of the picture, and a growbed filled with gravel raised above the level of the fish tank in the centre of the picture.



Water cress growing on a floating raft.

water and nutrients they need to grow, cleaning the water for the fish. There are bacteria that live on the surface of the gravel. This bacteria converts ammonia wastes from the fish into nitrates that can be used by the plants. This ammonia waste being converted into nitrates is often termed "the nitrogen cycle". This will be dealt with in more detail in another article in this issue.

Growbeds filled with a media such as gravel or expanded clay pebbles is a common method of growing plants in an aquaponic system, but there are many different methods that can be used. In fact any method of hydroponic growing can be adapted to aquaponics. Plants can be grown in floating foam rafts that sit on the water surface.

Vegetables can also be grown using NFT (Nutrient Film Technique), or through various other methods using a "run

to waste" style of growing. This is done by removing a percentage of the fish water each day and watering vegetables planted in different media such as coir peat, vermiculite, perlite etc. Many different species of fish can be grown in



Corn and tomatoes growing in NFT (Nutrient Film Technique) Photo—Jim

an aquaponic system, and your species selection will depend on a number of factors including your local government regulations. In future issues of the *Backyard Aquaponics Magazine* we will provide details of many different species of fish suitable for growing in aquaponic systems.

Quite high stocking densities of fish can be grown in an aquaponic system, and because of the recirculating nature of the systems very little water is used. Research has shown that an aquaponic system uses about 1/10th of the water used to grow vegetables in the ground.

An aquaponic system can be incredibly productive. I've produced 50kg of fish, and hundreds of kilograms of vegetables within 6 months in an area about the size of your average carport, 8m x 4m. This is a system that requires no bending, no weeding, no fertilizers, and only uses about the same power it takes to run a couple of light globes. ●

The Nitrogen Cycle

By Steve Cacchione

One of the most important yet least understood aspects of Aquaponics is the bacteria that we rely on and its function in the nitrogen cycle.

I know what you're thinking, bacteria (or "GERMS" if you watch a lot of disinfectant commercials) are meant to be bad, aren't they?

The fact is that there is good and bad in everything, even down to bacteria. Life wouldn't be possible without them.

Fish excrete ammonia. In a lake or ocean it's all good because the vast volume of water dilutes this ammonia. When you're keeping fish at home it needs to be managed as it is very toxic to the fish.

Decomposing food also creates ammonia. Some of the effects of excessive ammonia include:

- Extensive damage to tissues, especially the gills and kidney
- Impaired growth
- Decreased resistance to disease
- Death

Luckily nature's got it all sorted! Enter *Nitrosomonas sp.* This good little bacterium eats ammonia and converts it to nitrite.

Now, nitrite is much less poisonous to the fish than ammonia, but it's by no means a good thing. It stops the fish from taking up oxygen. Nature's got it under control

again, with *Nitrobacter sp.* This good bacterium eats nitrite and converts it to nitrate.

Luckily nitrate happens to be the favourite food of plants. Also the fish will tolerate a much higher level of nitrate than they will ammonia or nitrite. What you've just read is pretty much the nitrogen cycle. When an aquaponics system has sufficient numbers of these bacteria to completely process the ammonia and nitrites it is said to have "cycled".

Your goal should be to establish the nitrogen cycle quickly and with minimal stress on any aquatic life you may already have.

Once a system has a compliment of micro flora and fauna at work there seems to be an inherent synergy that allows wider environmental ranges to be accommodated.

Without their respective "foods" these bacteria will not exist in useful numbers.

This is why you will see an ammonia "spike" when setting up a new tank. The bacteria will increase their numbers

(reproduce) in response to an increasing ammonia load, so it makes sense that we would see a "spike" before they respond. Shortly after you have ammonia the bacteria will start reproducing and working away for you.

The same goes for *Nitrobacter sp.*, they'll only want to start reproducing and working once *Nitrosomonas sp.* is comfortable and producing lots of nitrite.

Now for a few facts on them:

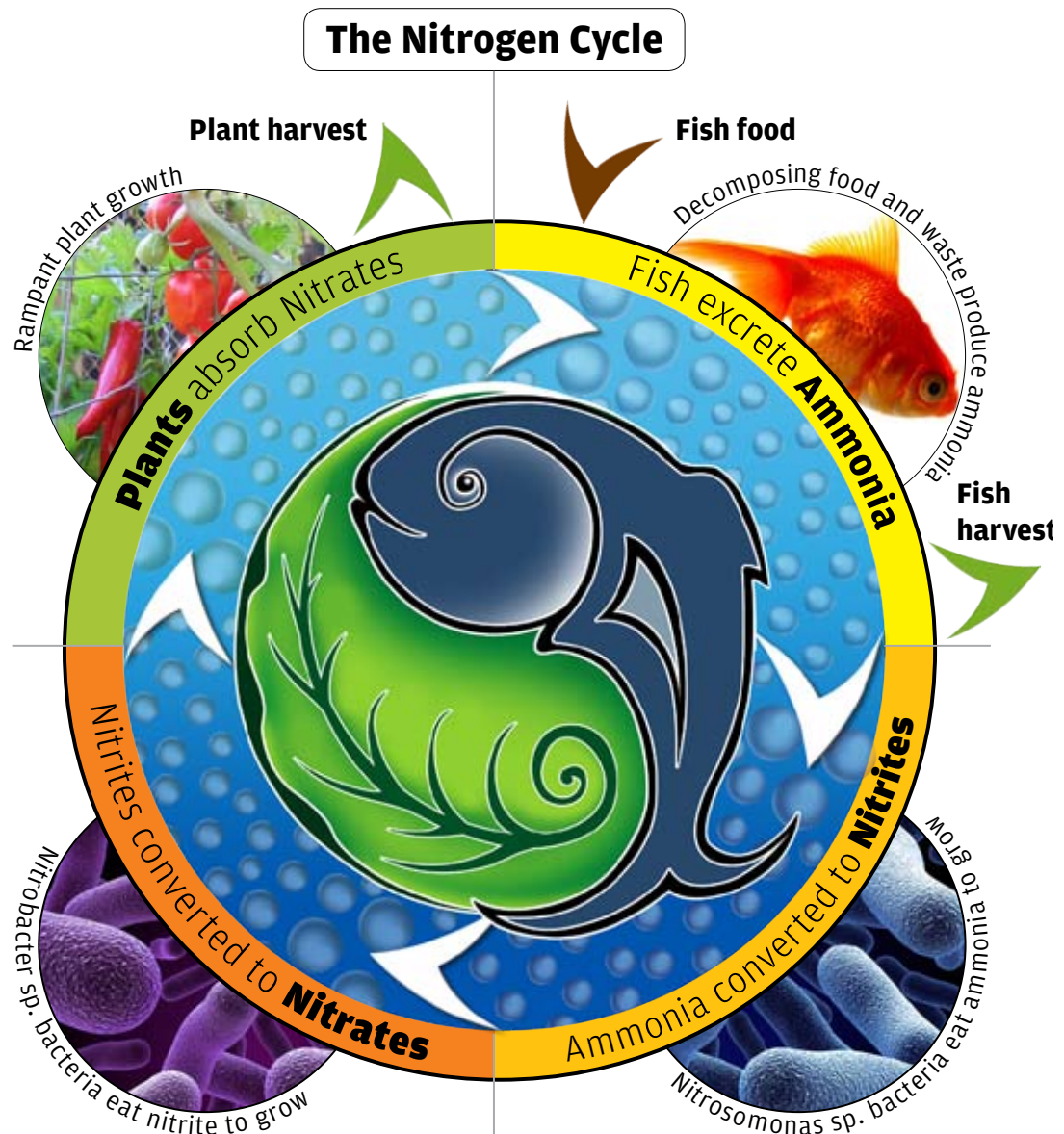
- They must colonize a surface (gravel, sand, synthetic biomed, etc.) for optimum growth.
- They need oxygen in the water to live and work.
- Nitrifying bacteria have long reproduction times.
- Under optimal conditions, *Nitrosomonas sp.* may double every 7 hours and *Nitrobacter sp.* every 13 hours. More realistically, they will double every 15 - 20 hours.
- To put that into perspective. In the time that it takes a single *Nitrosomonas sp.* cell to double in population, a single *E. coli* bacterium would have produced a population exceeding 35 trillion cells.
- As a general rule a brand new system will require about 4 weeks to cycle at around 20°C. It will take longer in colder water.
- Nitrifying bacteria cannot survive

in dry conditions or at sustained temperatures higher than 49° C .

- There are several species of *Nitrosomonas sp.* and *Nitrobacter sp.* bacteria and many strains among those species. Most of this information can be applied to species of *Nitrosomonas sp.* and *Nitrobacter sp.* in general, however, each strain may have specific tolerances to environmental factors and nutrient preferences not shared by other very closely related strains. Temperature and pH seem to be common.

Temperature

- The temperature for optimum growth of nitrifying bacteria is between 25° – 30° C (77° – 86° F).
- Growth rate is decreased by 50% at 18° C (64° F).
- Growth rate is decreased by 75% at 8° C – 15.5° C (46° – 50° F).
- No activity will occur at 4° C (39° F).
- Nitrifying bacteria will die at 0° C (32° F).
- Nitrifying bacteria will die at 49° C (120° F)
- *Nitrobacter sp.* is less tolerant of low temperatures than *Nitrosomonas sp.* In cold water systems, care must be taken to monitor the accumulation of nitrites.



pH

- The optimum pH range for *Nitrosomonas sp.* is 7.8 - 8.0.
- The optimum pH range for *Nitrobacter sp.* is 7.3 - 7.5
- At pH below 7.0, *Nitrosomonas sp.* growth will slow and increases in ammonia may become evident. *Nitrosomonas sp.* growth is inhibited at pH 6.5. All nitrification is inhibited if the pH drops to 6.0 or less.

Now, while one point you've just read indicates that *Nitrosomonas sp.* won't process ammonia at pH 6.0 or below, this was determined in a sterile lab culture. Similar research has shown that species of *Nitrosomonas sp.* in a natural environment such as soil will still process ammonia even at pH 4.0! This goes some way to explain why some of us have systems that are YEARS old with a pH of 6.0, no ammonia and happy fish. Once a system has a compliment of micro flora and fauna at work there seems to be an inherent synergy that allows wider environmental ranges to be accommodated.

I would definitely recommend that people strive for the above environmental tolerance ranges on initial system set up and the early life of their systems.

Many people with aquaponics systems try to maintain their pH at around 7.0 to 7.2 because this range satisfies the plants, fish and bacteria. The nitrogen cycle itself has a tendency to reduce pH, however it is pretty easy to keep pH at around 7.4 through the addition of calcium carbonate. Calcium carbonate increases pH, but will stop dissolving at pH around 7.4, meaning pH will stay pretty stable until all of the available calcium carbonate is depleted.

Readily available forms of calcium carbonate include:

- shell grit (available at many produce stores)
- sea shells

- calcium carbonate powder (available at many produce stores)
- limestone
- egg shells

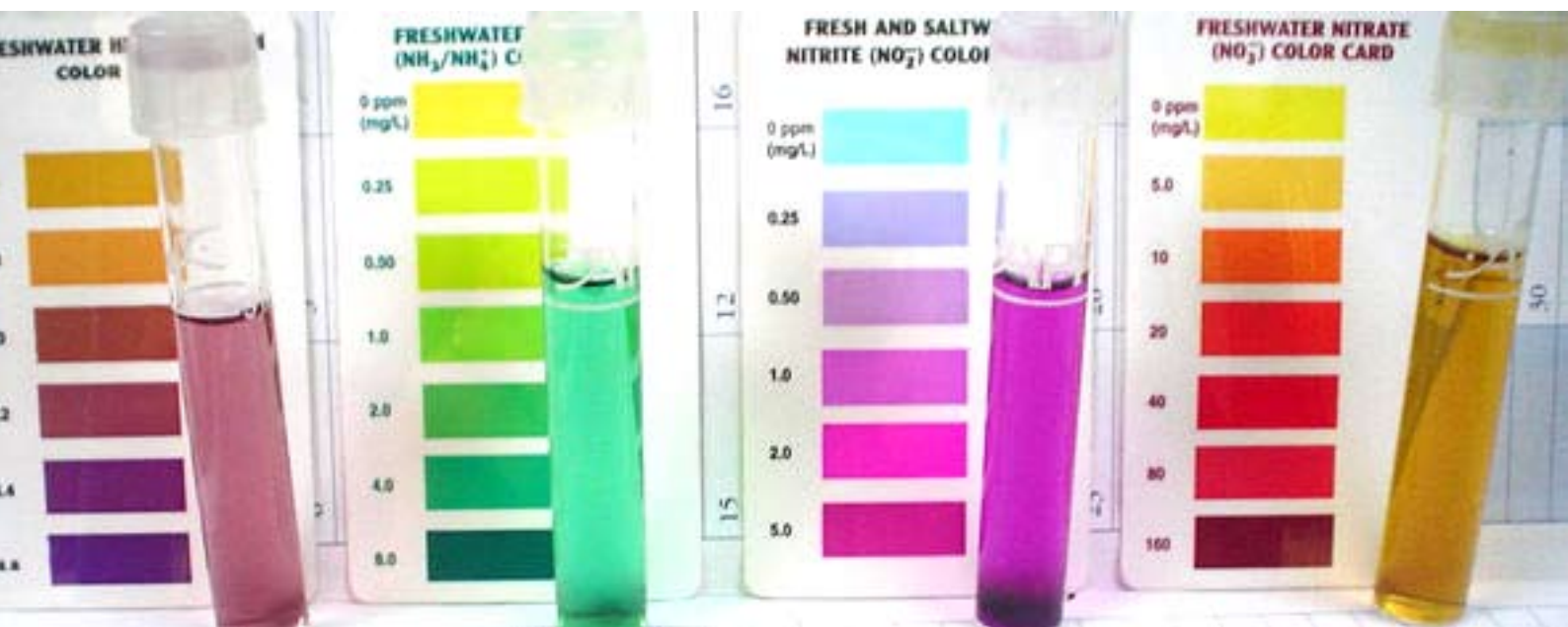
As mentioned there are many strains of nitrifying bacteria, each having their own water parameter preferences, so

Nitrosomonas sp. bacteria
eat ammonia to grow
and reproduce.

Nitrobacter sp. bacteria
eat nitrite to grow
and reproduce.

when cycling a new system its best to keep your water chemistry as stable as possible in relation to factors such as salt concentration. The number of fish used to cycle your system should be much less than your system is intended to hold. If too many fish are used the ammonia and nitrite will reach very high levels, which are likely to kill or cause permanent damage to your fish and will require you to undertake more frequent and larger water changes. Also, be sure not to overfeed the fish as this will also result in the production of more ammonia. Many people choose to use cheap goldfish for the cycling process, due to the minimal cost and their high tolerance to poor water conditions. The best advice you can take when cycling your system is to be patient and let nature take its course. Do frequent tests (at least daily) during this period and perform water changes as required.

Don't forget, fish will still excrete ammonia even when not eating, just not as much! •



VB's Backyard Lab

By Paul Ryan

In this edition of the *Backyard Aquaponics Magazine* readers are introduced to **VB's Backyard Lab**, a regular feature **In The Shed**.

The central tool in VB's Backyard Lab is a set of five independent micro Aquaponics systems. These will be used to complete various experiments. Each system comprises the following identical elements:

- a 50 litre glass aquarium
- a 600 litre per hour (at zero head) pond pump
- a 20 litre grow-bed

The remaining elements of the system are variable and will depend upon the experiment undertaken. These include:

- growing media (eg. gravel, expanded clay balls etc)
- nitrogen source (eg. finfish, crustaceans etc)
- irrigation method (eg. flood and drain, continuous flow etc)
- plants

In each edition, the details of at least one experiment will be discussed, with a focus on the relevance of results to the running of a full scale Aquaponics systems.

The first experiment has been planned and will soon commence. This will feature in the next edition.

Readers are invited to contribute ideas for experiments that they would like to see in future editions of the *Backyard Aquaponics Magazine* by e-mailing VB at paul@backyardaquaponics.com, using the subject line 'Experiment Idea'. ●



The Start of an Obsession

By Joel Malcolm

Dwindling native fish stocks, unsustainable farming practices and severe water shortages are bringing about a change in many primary production areas. As we all try and come

to grips with these issues, many people are beginning to think outside the square when it comes to food production. One more recent method of food production that's catching on in many areas around

the world is aquaponics, the combination of aquaculture and hydroponics.

Conventional intensive recirculating aquaculture can be very efficient at



Incredible plant growth in an aquaponic system.

producing large quantities of fish, though this method of aquaculture also requires large amounts of water to be changed out of the system on a regular basis. In a standard recirculating aquaculture system (RAS) generally 5-10% of the water is changed out of the system every day and replaced with fresh water. This discharged water is nutrient rich, and unless it's managed carefully then it can cause some major problems in waterways, especially waterways already suffering from depleted flows and other nutrient-rich run off.

For vegetable production, hydroponics is the most water efficient method of production available today, however, once again there's effluent that needs to be treated and/or disposed of. As the plants in a hydroponic system grow they use water in tissue production and in transpiration, the nutrient solution builds up dissolved salts over time that will become toxic to the plants. Hydroponic systems need to have the old solution flushed from the system, and new water and solution added on a regular basis.

A commercial hydroponic grower that I visited recently in Western Australia was using scheme water for his systems, and he was consuming \$12,000 worth of water a year. This was only a small scale producer who did all of the work himself with one part time employee.

So how can these problems be addressed? Here are two reasonably efficient methods of food production, but they still have some rather significant downfalls. The answer, Aquaponics.

Aquaponics combines aquaculture and hydroponics, helping to cancel out the negative aspects of each. In fact it not only cancels out the negative aspect of each method, but the symbiotic relationships formed in an aquaponic system create very complex ecosystems that actually increase the level of production when compared with the

individual methods. Before we get into too much detail I guess that I should explain the basics of aquaponics.

There are three essential components to an aquaponic system, fish, bacteria and plants. As part of a fish's normal breathing, they give off ammonia

In fact it not only cancels out the negative aspect of each method, but the symbiotic relationships formed in an aquaponic system create very complex ecosystems that actually increase the level of production when compared with the individual methods.

through their gills, also any fish wastes or uneaten food that breaks down in a fish tank gives off ammonia as part of the process. This ammonia will quickly build up in the water and fish are very susceptible to high levels of ammonia in their water. This is where the bacteria comes into the equation. There are two main types of bacteria that carry out the essential work, *Nitrosomonas sp.* and *Nitrobacter sp.* *Nitrosomonas sp.* bacteria digests the ammonia and converts it into nitrites. The fish are less susceptible to high levels of nitrites in the water, however most plants can't absorb nitrites. The *Nitrobacter sp.* bacteria then converts the nitrites into nitrates. The fish are happy with quite high levels of nitrates in their water,

plus the nitrates can be consumed by plants, and used for growth.

So, the fish give off ammonia which can be nasty at high levels, the bacteria converts the ammonia into nitrites and then nitrates, then the plants consume the nitrates from the water. The water is then returned to the fish tank cleaned of excess nutrients and freshly oxygenated.

It may sound a little complex to begin with, but in reality it's a very simple natural process that happens all around us in nature. The bacteria are naturally found everywhere, in streams, lakes, ponds, dams, and aquariums; they are found in the air, and will populate anywhere there is water and biological activity, like organic matter breaking down in water giving off ammonia.

Aquaponics today can take on many forms. Some commercial operations within Australia don't recirculate their water, it's used in their fish culture once, then pumped through a hydroponic system, before going out to waste. Personally I prefer recirculating systems, because of their miserly water usage, and that's the method I'm talking about here today.

Systems can also be designed to use a variety of different methods in the hydroponic component, for removal of nutrient. NFT (nutrient film technique), floating raft and gravel beds are all commonly used in aquaponic systems. Personally I prefer systems incorporating gravel beds for plant culture because the gravel beds act as a solids filter, a biofilter for bacteria growth, and a medium for the plants to grow roots into. Gravel beds provide the simplest system possible when it comes to designing, building and operating an aquaponics system. NFT and floating raft systems are very productive but require separate biofilters and solids removal that must be built into the design, so this tends to make a system a little more complex, and requiring further maintenance.

Our Favourite Tanks



Seedlings just starting to grow.

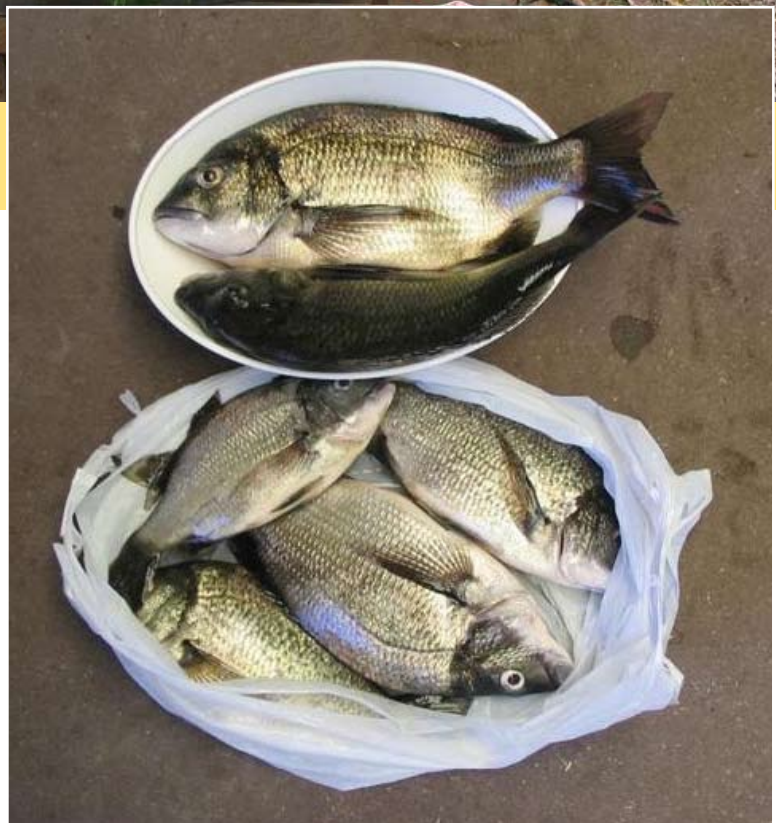


The same plants only 13 days later.



This is 25 days of growth after the first picture, a couple of cucumbers have already been harvested and there are many more on the way

I like to follow the KISS (keep it simple stupid) principle whenever possible, and this has led to the design of my present aquaponic systems. The large flood and drain system built using corrugated iron tanks and growbeds, produces well over 100kg of vegetables, and 50kg of fish in a six month period. Production here in Perth slows down a little over winter, but in warmer climates or enclosed in a greenhouse, this production can be repeated again over the cooler months. It's incredibly simple. Water is pumped from the fish tank into the gravel grow beds filled with growing plants. When the growbeds are full, the pump switches off.



Black Bream from the system above.

The water then slowly drains from the growbeds into a sump tank from where it's then pumped back into the fish tank. The system can be simplified even further if the fish tank is buried in the ground allowing the growbeds to drain straight back into the fish tank.

This system fits into an area about the size of a carport 4m x 8m, and that's without even trying. The round tank and growbeds make it awkward to fit into a rectangular area. If you wanted to use rectangular grow beds the system would fit into a much smaller area. All of the components used to build this system are standard off the shelf items bought from a hardware store and plumbing store, except the fish tank and the growbeds which are easily manufactured by a rainwater tank supplier. Similar size tanks

and growbeds could be sourced from plastics manufacturers. Plastic tanks would last longer and they are stronger and more durable than the steel, but at the time I was building this system steel was by far the cheapest method, and it has a certain rustic appeal that I liked.

This large flood and drain system has been running for almost 3 years now. I've found it to be very stable and robust requiring little to no maintenance. All that has to be done is feed the fish, top up the water every few days, plant seedlings, and harvest the fish and vegetables. The only other things added to this system are chelated iron, about 2 spoons every 6-8 weeks, or whenever signs of iron deficiency are showing in the plants. I also add seashells to my drain tank to help buffer the pH.

Aquaponic systems tend to go acidic over time because of the biological activity in the system, so you can either add garden lime, or seashells. I prefer to add seashells because they are self regulating. When the pH is low the acidic water dissolves the seashells raising the pH back towards neutral. When the water is neutral the shells won't dissolve. It's a fantastic way to regulate pH while also adding micronutrients and elements that have been trapped inside the seashells during their formation in the ocean.

In the past I had added regular applications of seaweed extract to the system, but I have found this to not be as necessary lately as most other nutrients required by the plants come from the fish feed, so long as you are using a quality feed. Seaweed extract



This system can produce 50kg of fish in 6 months.

can be added if signs of deficiencies become evident.

Dr. Nick Savidov is a Canadian researcher that has been researching inorganic hydroponics for 20 years. After hearing about aquaponics he decided to put it to the test against normal inorganic hydroponics. In the first 6 months of production the inorganic hydroponic growth was found to exceed aquaponic growth, this is because an aquaponic system takes time to mature and build up the complex ecosystem of bacteria and micro flora and fauna in the system.

Further trials found that after 12 months the aquaponic system growth rates began to outstrip the growth of the inorganic hydroponics by almost double with many plant species. After 2 years the aquaponic system was found to have matured even more, and had reached it's optimum production level, with some plant species outgrowing the inorganic plants, at over double the growth rate. Unsure as to why this was happening, and because he had been a skeptic of aquaponics with a firm grounding of 20 years in inorganic hydroponics, he decided to really put things to the test. He examined the aquaponic water for all of the macro and micro nutrients, and then reproduced an inorganic hydroponic solution that had the exact same levels of macro and micro nutrients as the aquaponics. Yet still aquaponic plant growth far exceeded inorganic hydroponic growth.

Not only has the aquaponic plant growth been found to exceed inorganic plant growth, fish in an aquaponic system suffer less from diseases than those in a sterile aquaculture system. Many recirculating aquaculture systems sterilize the water to remove pathogens from the system. In an aquaponic system you can't sterilize the water because you need the microbial activity to perform its job in the complex ecosystem.

For many conventional producers this may seem like a recipe for disaster,



Further trials found that after 12 months the aquaponic system growth rates began to outstrip the growth of the inorganic hydroponics by almost double with many plant species

however, studies have been finding that the fish become more resistant to disease in an aquaponic system.

These unknown growth factors in plants, and disease resistance in fish in an aquaponic system, are only fairly newly discovered things in scientific circles, and as yet the answers still haven't been found as to exactly why it's happening. More research is going to be carried

out into aquaponics and the 'unknown factors' in the coming years.

To give you an idea of plant growth rates in an aquaponic system, on pages 12 & 13 I've included some before and after photographs. This system has a 4000 litre fish tank with about 10-12 Kg of fish, and only a very small growbed. Water is pumped from the fish tank up through an irrigation pipe on top of the gravel growbed. The irrigation pipe has holes drilled in the underside. The water flows through the gravel and out of a hole in the bottom of the growbed, straight back into the fish tank. The ultimate in simplicity really.

The only downfall of aquaponics is that it still relies on power to pump the water, and commercial feed pellets for the fish. Power consumption in an aquaponic system is reasonable, with my large flood and drain system consuming less than 150W continuously. Smaller systems consume even less power and it's quite feasible to run a system on solar power.

On the feed side of things, this is an area that more effort is being put into recently. Fish feed can be supplemented in a number of ways. Black soldier fly larvae have been found to be very easy to raise on food scraps, and they are self harvesting when a little thought is put into designing their culture container. Worms can be fed on the vegetable scraps from the growbed, and although they are a little more difficult to harvest they're a very nutritious feed for fish. Even bug zappers placed over fish tanks can provide a fairly small, constant source of self harvesting insects during the evening. In recent studies, lupins have been found to contain an almost complete diet for many species of fish, and many people are experimenting

All of the vegetable scraps produced in the system are fed to the worms, then the worms are fed to the fish.

with different recipes for home made pellet feed.

One such simple recipe developed by an American aquaponics pioneer contains 1 part whole wheat, 1 part sprouted wheat, whole eggs (including shell) and sea salt for minerals. Munched up through a mincer and extruded onto trays before being dried, he feeds his fish on an

exclusive diet of these pellets and other green feed.

Many native fish in Australia are suitable for growing in an aquaponics system. Carnivorous fish such as Barramundi or Murray Cod are great, but they can only be fed a diet of pellets, worms, bugs etc. Omnivorous fish can be fed a mixed diet, and the main species cultivated in Australia are Silver Perch and Jade Perch.

At the moment I'm working on designing systems that can close the loop and do away with pelletized feeds. The system pictured above is constructed predominantly from recycled materials. The fish tank is buried in the far corner and consists of a 1000L second hand IBC.



A system constructed predominantly from recycled materials.



A large 6 growbed modern system.

Burying the fish tank allows for the use of only one pump, with all water returning to it under gravity. Water is pumped out of the fish tank and then off in two directions, one flow goes to the gravel growbeds on the right hand side, the other flow goes to the top half barrels on the left. The left hand side consists of two tiers of second hand barrels cut in half. These barrels are for growing yabbies to eat, as well as growing duckweed and Azolla sp. on the surface of the water to feed to the silver perch growing in the fish tank.

Underneath both sides of the system are half barrels for worm culture. All of the vegetable scraps produced in the system are fed to the worms, then the

worms are fed to the fish. The whole system runs on one 70W pond pump that I'm hoping to convert over to a solar supply when I can find some panels at the right price. This system is self contained in an area of 15m² and I'm expecting that when it gets up to full 17 production it's going to produce a fair amount of food from a very small area, and soon it will be running with no external inputs. Aquaponics is set to be a growing system that we will hear a lot more of in the future. With serious water shortages effecting most of Australia, and nutrient run off and pollution becoming major issues, we can't afford not to look at alternative growing methods like aquaponics. After all, what other growing methods are non

polluting, have zero waste, zero runoff, and require only top up water because of evaporation and transpiration. Aquaponics can be scaled from a tiny desktop system in an aquarium to a medium sized backyard system, right up to large commercial systems that produce tons of fish and vegetables every month.

In Australia we are already showing signs of becoming a major developer and innovator in aquaponics, even though it's still a relatively new field in Australia. As more people are hearing about aquaponics, it's not only being adopted by commercial growers, but it's becoming a very popular production method for smaller backyard producers as well. ●

Road testing pumps



In future editions we will road test all different types of aquaponic equipment to determine their suitability and reliability for aquaponics systems. In this edition we will look at the **Ebara Optima** pump, formerly known as “Best Zero”.

Ebara are an Italian pump company that make a wide range of pumps and the ‘optima’ is the smallest pump that they produce in their range.

I’ve been using the “Optima” (formerly Best Zero) for many years now in many different systems and I’ve found them to be a solid reliable pump. They are capable of pumping soft solids up to 10mm which means they can pump the solids out of the fish tank into the growbeds with ease. The pump is not rated for continuous pumping and with a flow rate of 8000L/h at 1.5m head, you probably wouldn’t want to run it continuously anyway. This pump is only suitable for larger aquaponic systems.

The pumps I have used have been reliable, one I ran continuously for over 2 years even though they are not rated for continuous use. Another pump that was in my drain tank blew a seal in the top of the pump after about 12 months. This was a known issue with the old “best zero” model and the pump was replaced without question. This issue with the seal has been fixed in the new Optima model according to their Australian representative, and I have not had any issues with the new Optima model.

In wrapping up, they are a solid little pump that will move a lot of water and solids, though are not rated for continuous operation. ●

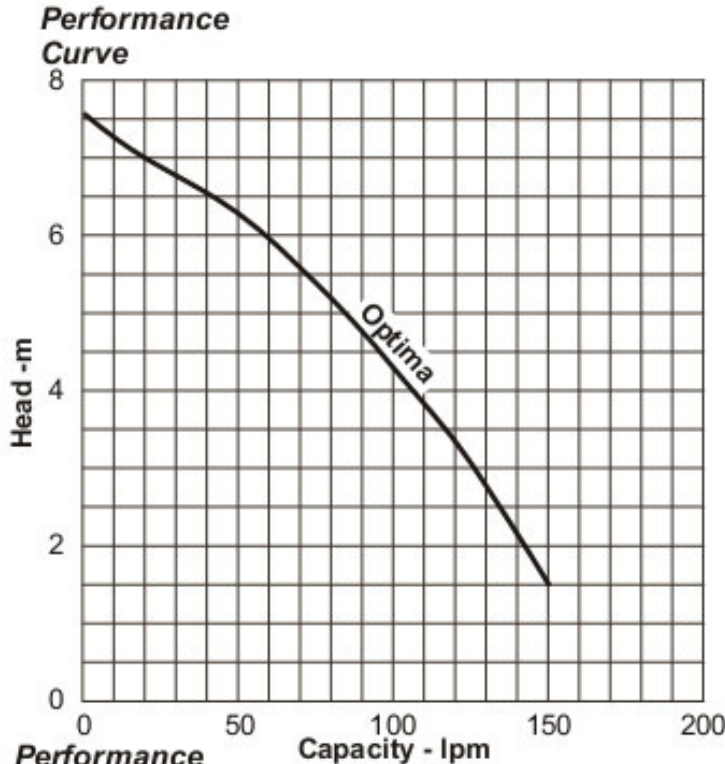


Optima MA
Automatic pump
with Float Switch

With
Mechanical
Seal



Domestic sump pump manufactured in stainless steel and thermo plastics with a mechanical seal. Suitable for many dewatering usages, including:- ● draining wells, basements, cellars, etc. ● emptying of tanks & drums ● general transfer of clean water.



Performance Table

Pump Model	Motor Output	Discharge Ø mm	Power Supply	Full Load Current	Capacitor (1Phase models only)	Q= Capacity - litres/min						
						0	20	50	75	100	125	150
Optima	0.25 kW	32 mm	240V, 50Hz, 1Ph	1.9 A	8µF	7.6	7.0	6.3	5.4	4.3	3.1	1.5

Specifications

- Submersible pump with semi open impeller
- Maximum solids handling 10 mm
- Maximum liquid temperature: 50°C
- Maximum submergence: 5m

Materials

- Pump casing: 304 Stainless Steel
- Impeller: Thermo plastic (PPE + glass fibre)
- Outer casing: 304 Stainless Steel
- Shaft : 303 Stainless Steel
- Motor frame: 304 Stainless Steel
- Motor Cap: Polypropylene
- Fasteners: 304 Stainless Steel
- Seal: Carbon/Ceramic Mechanical Seal in oil lubricated chamber, Upper Lip Seal

Motor Data

- Air filled, dry submersible, 2 pole motor
- Insulation class F
- IP68 protection
- 50 Hz, 1 phase, 240 Volt
- In built overload protection

Cable

- 5m of cable (with plug)

Range

- 32mm discharge
- 0.25 kW motor
- Single phase, automatic or manual versions
- Magnetic Switch version available

Options



Optima MS
Automatic pump
with Magnetic Switch



Optima M
Manual
Pump



Low level
suction "skirt"
(down to 3mm)



Plants that grow well in aquaponics

In future editions we will examine different plants grown in aquaponic systems.

By Jaymie Rains

Aquaponics allows you to grow many of your household's favourite vegetables in a controlled organic environment. In the many Backyard Aquaponic systems, not many vegetables have been found to be unsuitable.

Depending on your own geographical location and the size of your aquaponic



Stuart with a nice selection of aquaponic vegetables.



system, weekly grocery shopping can be significantly reduced. This is a very good thing during these times of food safety uncertainty and rising costs.

Systems in cooler areas will easily supply you with all the leafy vegetables you could eat: broccoli, cauliflower, cabbages, celery, lovely lettuces and silverbeet. But it is not just leafy veggies that can grow in aquaponics systems. Many fruiting plants grow very well too.

Tomatoes are prime examples. In the last year, one tomato bush in Joel Malcolm's system produced more than 34Kg of fruit! And yes, that was from one enormous bush! Capsicums, egg plants, strawberries, peas and beans all thrive in the marvellous environment. A wide variety of herbs also enjoy aquaponic life: parsley, basil, thyme, mints, lemon balm, chives, rosemary and watercresses.

In future issues we will be looking at different plant species in more depth, comparing their growth rates and production levels in aquaponic systems. ●



Three different tomato varieties grown in an aquaponicsystem.



Habanero chills..



A healthy crop of silverbeet, broccoli, celery and tomato plants growing well

After the harvest

By Paul Ryan

Although some of us may have fantasised about harvesting and eating fish grown in the backyard, before coming across Aquaponics common sense suggested this was impractical if not impossible to accomplish. It is normal to have some residual doubts about Aquaponics until you have harvested your first fish and/or plants. It just seems too good to be true. Early on, this feeling can be heightened if you experience issues with fish health, which is one reason why a two-part series focussing on fish health is included in this and the next edition of the Backyard Aquaponics Magazine.

To celebrate the fantastically yummy outputs of Aquaponics, in each edition of the magazine, this section will include fabulous recipes using Aquaponics system produce, as well as handy cooking hints and tips. Although fish and crustaceans will inevitably feature heavily, vegetarian readers will not be forgotten. Readers are invited to submit their favourite Aquaponics produce recipes for publication, along with a picture of the final product, if possible.

Email your submissions to magazine@backyardaquaponics.com with the subject line 'Recipe Submission'.

To tempt and tantalise tastebuds and preview what readers can expect from their own Aquaponics systems, a selection of pictures have been compiled for this edition, featuring fish harvested from Backyard Aquaponics Forum member systems. ●



Jade Perch for dinner. Photo P. Ryan





Some Backyard aquaponic produce with some eggs. Photo J. Rains



Jade Perch ready for the pan. Photo S. Cacchione



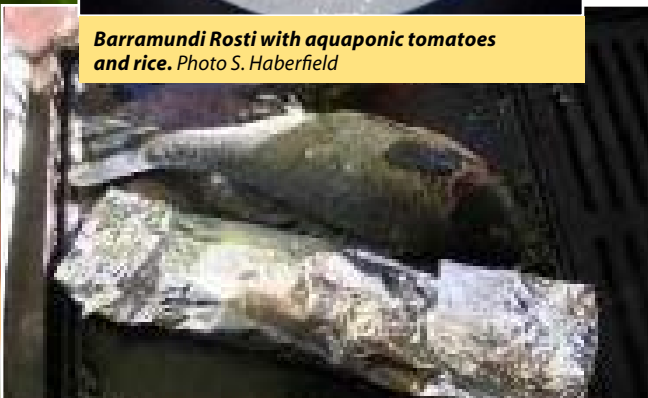
Silver Perch, each approximately 400g. Photo J. Malcolm



Barramundi Rosti with aquaponic tomatoes and rice. Photo S. Haberfield



Barramundi for lunch. Photo S. Haberfield



Silver Perch on the barbeque. Photo J. Malcolm

Jade Perch?

By Jaymie Rains

Jade Perch (*Scortum barcoo*), Barcoo Grunter or Striped Perch is one of the favourite species of fish used in Australian backyard aquaponics systems. They are a fast growing, hardy fish that tastes great, with extraordinarily high omega-3 levels making it one of the healthiest fish available (**CSIRO <http://www.marine.csiro.au/media/02releases/>**

13may02.html). What more could you want?

Jade Perch is a heavily built fish with a small head, generally uniformly brownish-black with darker "birthmarks". The fins are usually darker in colour than the body. The fish shown in this article have some of the characteristic "birthmarks", the jade colouring along the

dorsal area and the general "football" shape of the body.

Jade Perch is a freshwater finfish native to the low gradient rivers and creeks of the Lake Eyre catchment. These waters are generally highly turbid and have a wide temperature and conductivity or salinity range. In their natural habitat, Jade Perch spawn



during the summer floods when water temperatures are higher.

In captivity the sexually mature broodstock are induced to spawn with a hormone injection. This is not usually an option for backyarders.

They have been found to grow well in recirculating systems and ponds. They hate the cold, and love the heat. Therefore, for out-door tank or pond production, they are probably only suitable for tropical or sub-tropical climates. Seemingly, they have a much higher metabolic rate, therefore to avoid water quality problems should be stocked at a much lower rate than Silver perch.

They feed eagerly on anything you might throw in to tanks: worms, caterpillars,



Six month old Jade Perch. Photo J. Rains



Hungry Jade Perch and Silver Perch. Photo J. Rains

grasshoppers, beetles, bugs, snails, algae, duckweed, leafy vegetables and beans; all readily available from many Backyard Aquaponic systems. Most hatcheries will train fingerlings to accept artificial diets, usually as pellets, with the pellet size varying with the size of the fish. The food conversion ratios (FCR) vary depending upon the level of management with 1.2:1 for fingerlings to 1.6:1 for growout being achievable. This means for every 1.2 kilograms of food the fish consume, they will gain one kilogram. Care should be taken when feeding, as Jade Perch are voracious feeders and overfeeding can occur, leading to ammonia spikes in the system.

Table-sized fish of 350 to 800gms can be grown in 8 to 15 months in outdoor ponds and tanks. The advantages of growing Jade Perch in your Backyard Aquaponics system:

- Jade Perch has the highest Omega-3 oil content compared with over 200 seafoods tested by CSIRO. Scientific research has proven that Omega-3 can help strengthen and protect cells in the body, especially cells in your heart, brain and joints.
 - Jade Perch has up to 100 times more Omega-3 oil than chicken, beef or lamb.
 - Jade Perch contain lower levels of cholesterol.
 - Jade Perch has clean white flesh and a delicate flavour with a melt-in-your-mouth texture.
 - Temperature (optimum) 22°C – 28°C (71°F – 82°F)
 - Temperature (tolerate) 13°C – 32°C (55°F – 90°F)
 - Aeration and water exchanges need to be increased with higher temperatures.
 - Growth is negligible below 20°C (68°F).
 - Feeding should cease below 16°C (60°F)
 - Salt at 5ppt is acceptable for long term exposure and for treatment of ectoparasite and fungal diseases (e.g. Ichthyophthirius multifiliis)
 - Dissolved Oxygen 4mg/L or greater.
- Jade Perch environmental preferences**
(from <http://www2.dpi.qld.gov.au/fishweb/14076.html>)



A healthy year old Jade Perch. Photo P. Ryan



Healthy Fish are Happy Fish..

By Paul Ryan

All sorts of people are attracted to Aquaponics. Some have previous experience in keeping fish, mainly ornamental aquarium fish, but most have little or no experience in this area. Although it is not difficult to manage the fish-keeping side of Aquaponics, a lack of knowledge of fundamental principals and practices is likely to result in major fish losses and a delay in reaping the fantastic rewards provided by a well functioning Aquaponics System.

The purpose of this two-part article is to help current and prospective Aquaponics system owners establish a balanced healthy environment for their fish friends, by outlining key fish keeping principals and practices. The information provided will also help in diagnosing problems

that might be experienced along the way. Aspects important to fish health that are covered by this series are:

- Temperature
- pH
- Ammonia, Nitrite and Nitrate
- Dissolved Oxygen
- Water Contamination
- Disease Temperature

Each species of fish has a temperature range within which they can live healthy lives and a more narrow range within which they will thrive. The ranges vary from species to species, so it is important

to know what they are for the ones you are growing.

Sudden changes in water temperature can also have an adverse affect on fish health. When doing system top-ups or other water additions, it is important to make sure that the temperature of the water being added to the system is very similar to that of the existing water or that the water is added very gradually to allow the fish to adjust to the change in temperature.

When introducing newly purchased fish to your tank, it is important that you acclimatise them to the existing tank temperature. One common method of doing this is to float the bag, within which they are contained, in the fish tank for at least 30 minutes before

release. For more detailed information on acclimatising your new fish, see **I Got a Bag of Fish. Now What?** (<http://backyardaquaponics.com/forum/viewtopic.php?t=1740>).

Do not discount the importance of temperature as a long term factor in running a successful Aquaponics system. When setting up your system and choosing the type of fish that you will grow, it is essential that you consider the extremes of winter and summer and have suitable means of maintaining water temperature within the desired range during these periods. Using large amounts of non-renewable energy to heat or cool your water will incur both financial and environment costs. Strategies to address this issue can include:

- Insulating and covering tanks to stabilise temperature, retaining heat in winter and coolness in summer;

- Housing the plants in a suitable structure to provide some shade in summer and heat retention in winter; and, most importantly

- Growing fish that are suited to your climate.

During winter, at night some people also choose to turn off the pumps that supply water to growbeds in order to minimise heat loss. This is a valid practice but it is important that this is not done unless:

- Aeration of fish tanks continues throughout the night by means of an air pump or some other method;

- Grow-beds are able to drain of water, thereby ensuring that plant roots have oxygen available to them while the pumps are not running;

- If the grow-beds are the only means of bio-filtration, that during the night

ammonia and nitrite are not at levels that can adversely affect the health of the fish. Fish will continue to respire and produce ammonia throughout the night; and

- There are means to ensure that the pumps are switched on again in the morning, for example a reliable automatic timer switch. Water temperature also has an effect on the dissolved oxygen content. This is discussed further later. It is important to also realise that temperature will affect the efficiency of bacteria in the nitrogen cycle – see the Nitrogen Cycle article earlier in this issue for more information on this.

pH

Like temperature, suitable pH range varies with different fish species. A pH level that is outside of the preferred range will have a negative affect on fish health. Damage to the fish's slime coat will make them more prone to disease. Respiratory issues may also result due to the pH affecting gill function.

As well as keeping your tank within the healthy range, it is important to avoid major fluctuations within this range over short periods. Fluctuations will stress your fish and could result in death or increased susceptibility to disease. Although the suitable range will vary between species, most freshwater fish can be permanently kept at pH within the range 5.5 to 7.5 and many have a wider range.

Some important things to know about pH:

- On the pH scale 0 to 14, 7 is neutral (neither acid nor alkaline). Values below 7 are acid and above are alkaline;

- The pH scale is logarithmic. As pH moves away from 7, each step down/up is 10 times stronger than the last. To put this simply, pH 6 is 10 times and pH 5 100 times more acidic than pH 7. This explains why pH swings of just a couple of units



can seriously affect fish health;

- Carbon dioxide is acidic when dissolved in water. Fish produce carbon dioxide day and night. Although algae and other plants in the fish tank will produce oxygen while photosynthesising during the day, at night they produce carbon dioxide. This is one reason why pH tends to be lower in the morning than at night in a system that is not adequately buffered;

- During nitrification, ammonia and oxygen are converted to nitrite, hydrogen and water. Because hydrogen is acidic, nitrification pushes pH down; and

- Calcium carbonate (CaCO₃) can be used to buffer the system against pH swings. CaCO₃ increases pH, but will stop dissolving at pH around 7.4, meaning pH will stay pretty stable until all of the available calcium carbonate is depleted. Readily available forms of calcium carbonate include:

- shell grit (available at many produce stores)
- sea shells
- calcium carbonate powder (available at many produce stores)
- limestone
- egg shells.

Ammonia, Nitrite and Nitrate

Ammonia, nitrite and nitrate are all forms of nitrogen that exist within any Aquaponics system. As is detailed in the article 'The Nitrogen Cycle', also featured in this edition (page 4), beneficial bacteria within an Aquaponics system convert ammonia to nitrite and nitrite to nitrate. Nitrate is then utilised by plants grown in the system.

Short-term exposure to even a small

concentration of ammonia or nitrite can result in death or permanent damage to fish. Although less toxic, at higher concentrations nitrate will also still harm fish over the long term.

“Short-term exposure to even a small concentration of ammonia or nitrite can result in death or permanent damage to fish.” “Water temperature also has an effect on the dissolved oxygen content.”

Ammonia

Within an Aquaponics system, a large quantity of ammonia is produced. There are two primary sources of ammonia. Firstly, fish excrete ammonia, the bulk of which enters the water from their gills. Secondly, ammonia is produced through biological conversion of dissolved organic matter such as uneaten fish food particles, fish poo and dead plant matter within the grow-beds (eg. old roots).

It is important to realise that ammonia exists in two forms, ionised and un-ionised. As temperature and pH increase, so does the % of total ammonia that exists in the un-ionised form. It is un-ionised ammonia that is most toxic to fish because of its ability to be absorbed by the fish across their gills. Ionised ammonia is only harmful in high concentrations and is not likely to be an issue in an Aquaponics system.

Most common test kits do not test for each form of ammonia, but rather give a

measurement that represents the total ammonia nitrogen (TAN), which consists of both ionised and un-ionised ammonia. Provided that TAN, pH and temperature are known, the amount of un-ionised ammonia can be easily calculated using tables that are readily available on the Internet.

As a general rule the level of un-ionised ammonia should be kept below 0.02 parts per million (ppm). **Table 1** shows an approximation of the maximum TAN that is safe for fish at various pH and temperature levels. Regardless of this, when using commonly available test kits, an ammonia reading of 0ppm total ammonia should be the aim for a balanced Aquaponics system. This is achieved due to the efficient processing of ammonia by the beneficial bacteria housed within the system.

Nitrite

At rates as low as 0.5ppm, nitrite can be harmful to your fish. Nitrite affects the ability of the fish's gills to efficiently transfer oxygen to bloodstream. This issue becomes more significant at lower oxygen saturation levels, for example when the temperature of the water is high.

It has been shown that the addition of chloride will reduce the absorption of nitrite across a fish's gills and therefore assist in reducing the toxicity of nitrite. Salt (sodium chloride) added at a rate of 17ppm (17 grams per 1000 litres) for each ppm of nitrite will reduce the effect of nitrite. Some people keep 1 gram per litre of salt in their systems on a permanent basis for therapeutic purposes, as a stress reliever and aid to disease recovery. Of course this level is more than enough to also complete the function of nitrite toxicity reduction.

As salt will not entirely eliminate the harmful effects of nitrite and at higher concentrations can also affect the health

of some plants, the preferred method for guarding against nitrite poisoning is to ensure that cycling is properly completed and nitrite spikes are avoided by maintaining a balanced system. For example, avoid the temptation to make sudden significant increases in the rate of feeding. Also, ensure that preventative measures, such as water changes, are employed to address the short term inability of beneficial bacteria to process the increased production of nitrite (and ammonia) caused by any significant increase in fish population density.

Nitrate

Various fish species have differing tolerances to nitrate. Even populations within the same species will often have different tolerances, depending upon the conditions within which their ancestors have lived.

It is essential that you consider the extremes of winter and summer and have suitable means of maintaining water temperature

Generally speaking, the most common species of eating type fish grown in Aquaponics have a relatively high tolerance to nitrate, with levels of 80 to 160ppm having been proven by BYAP forum members to present no short term issues.

For ornamental aquarium fish, it is normally recommended that nitrate levels be maintained below 20ppm in the long term. The reason for this is that elevated levels of nitrate can have a negative effect on the internal organs of fish. When growing fish for harvest, this is less of an issue as fish will normally be harvested well before any of the negative effects of exposure to moderate levels of nitrate present themselves.

As it is the plants in an Aquaponics system that remove the nitrate, to ensure nitrate does not become an issue it is important that an appropriate level of planting is maintained. What is appropriate will depend on a number of factors including amount of fish (weight), feeding rate and type of plants. The rest of this great article will be in next season's issue of the ***Backyard Aquaponics Magazine.*** ●

Total Ammonia Nitrogen (TAN) – (ppm)											
Temp (°C)	pH										
	6.0	6.4	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4
4	200	67	29	18	11	7.1	4.4	2.8	1.8	1.1	0.68
8	100	50	20	13	8.0	5.1	3.2	2.0	1.3	0.83	0.5
12	100	40	14	9.5	5.9	3.7	2.4	1.5	0.95	0.61	0.36
16	67	29	11	6.9	4.4	2.7	1.8	1.1	0.71	0.45	0.27
20	50	20	8.0	5.1	3.2	2.1	1.3	0.83	0.53	0.34	0.21
24	40	15	6.1	3.9	2.4	1.5	0.98	0.63	0.4	0.26	0.16
28	29	12	4.7	2.9	1.8	1.2	0.75	0.48	0.31	0.2	0.12
32	22	8.7	3.5	2.2	1.4	0.89	0.57	0.37	0.24	0.16	0.1

Table 1 – Safe Level of Total Ammonia Nitrogen (TAN)

What's happening in the world of Aquaponics

There have been a few gatherings of **Backyard Aquaponics folk** over the last year. Here are some photos of a few of them.

In future issues we would like to show more of these get togethers.

That is a big hint for you to get out there and meet other Aquaponicists!



Western Australia had a meet at Joel Malcolm's marvellous backyard to see THE Backyard Aquaponics System.
November 2006. Photo J. Malcolm

As aquaponics **grows** we hope there will be more of these fun and informative gatherings, sharing the enthusiasm and knowledge of aquaponics with more people.



*In January 2007, some of the Victorian enthusiasts gathered at Food&Fish's house.
January 2007. Photo M. Matthews*



*Over the Easter weekend, keen Backyard Aquaponicists journeyed from many and varied places around Queensland, converging at Aquamad's home in Cairns.
April 2007, Photo J. Rains*

Need further information about aquaponics? Would you like to look at building your own system, or would you rather have a system installed for you?

The Backyard Aquaponics shop is now open!

The first of it's kind in the world. A retail shop and display centre in Western Australia specializing in aquaponics products, information and systems, open to the public during standard retail hours. Come down and have a look. We have a complete range of books, DVD's, CD's, tanks, pumps, growbeds, pipe work and fittings, as well as many different systems.

Throughout 2008 we will be running a series of short courses on aquaponics in conjunction with Faye Arcaro from Aquaponica. Register your interest now by contacting Faye or myself.

If you're interested in any further information about aquaponics, or any products mentioned above, please contact us now or drop by the shop for a look around.



You can install the system yourself if you feel confident in your skills, or you can incorporate our complete delivery and installation service. Installation provides you with the peace of mind that your aquaponic system will be working first time without any effort required by yourself.

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So you want a backyard Aquaponics system installed at your house, but you'd like some advice first?

Please contact us now and book an appointment. For \$160 we will come and check your site to ensure that there is access for the equipment and materials, and discuss the best possible design layout for your personal requirements. We will then design your system to suit your requirements using 3D software, and send you the plans to suit. The \$160 will then be deducted from the final purchase price should you decide to go ahead with the purchase of a system.

Presently these Backyard Aquaponics systems are only available in Western Australia but they will soon be available Australia wide.

The Backyard Aquaponics shop and display centre is now open in Jandakot on the corner of Berrigan drive and Jandakot Rd. Please feel free to come down and have a look at how aquaponics works, and to see some of the systems available.



Contact Joel Malcolm or Faye Arcaro
 PO Box 3350, Success, W.A. 6964
 Ph: 9414 9334
 Mob: 0402 418 548
www.backyardaquaponics.com

Backyard Aquaponics is a West Australian owned and operated company. The systems have been designed and constructed to suite our local conditions and all growbeds, fish tanks and stands are made locally here in W.A.





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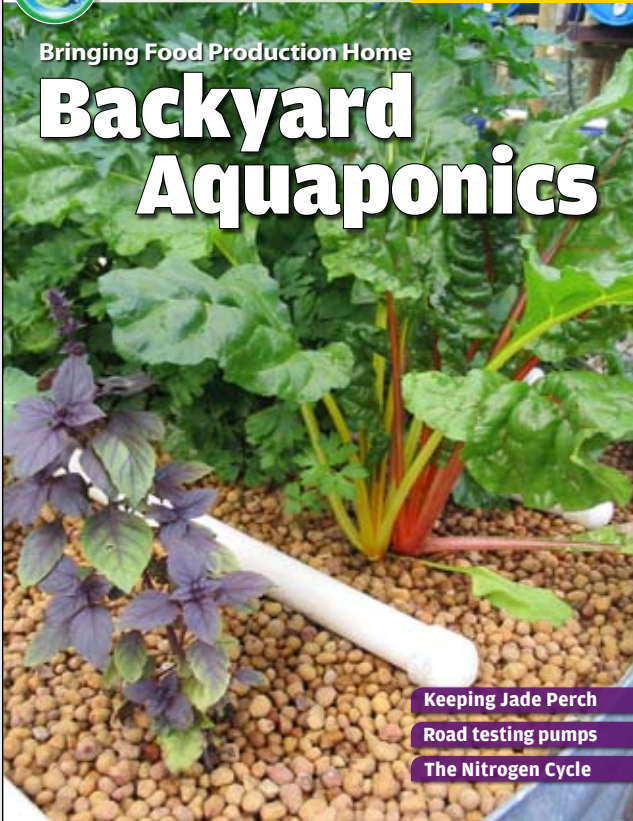


The No.1 Aquaponics magazine for the backyard enthusiast.

ISSUE 1 • Summer 2007

Bringing Food Production Home

Backyard Aquaponics



Keeping Jade Perch
Road testing pumps
The Nitrogen Cycle

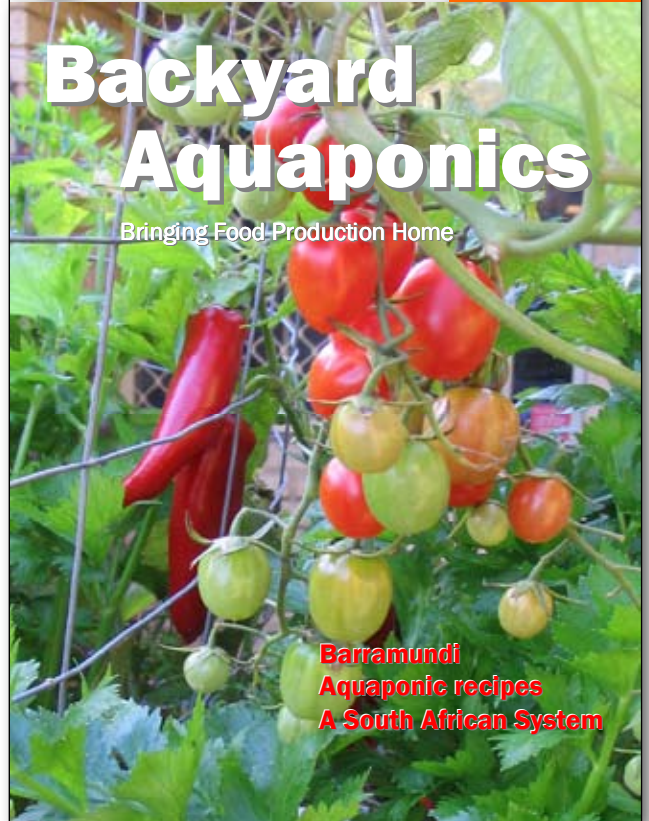


The No.1 Aquaponics magazine for the backyard enthusiast.

Issue 2
Second Quarter 2008

Backyard Aquaponics

Bringing Food Production Home



Barramundi
Aquaponic recipes
A South African System

Backyard Aquaponics Magazine Future Editions and Subscriptions

Work is well under way on the third edition of the magazine. We will be showcasing more systems that belong to members of the online discussion forum, there will be information about fish feed and fish diseases, and we'll have an in-depth look at another fish species suitable for use in aquaponics systems. One of the new items to look forward to in the next issue, is a **question and answer** section where we will take some of the most commonly asked questions about aquaponics and provide you with straightforward answers from experienced aquaponic system operators.

It's promising to be an exciting issue, packed full of information, pictures and diagrams and we hope to see you then.

**Issue 2
OUT
NOW**

The **Backyard Aquaponics Magazine** can be purchased and downloaded from the Backyard Aquaponics magazine website either as individual issues, or as a yearly subscription. Alternatively, we can mail you a copy of the magazine on CD-Rom, or DVD.

If you have any queries, please don't hesitate to contact us.

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