Government of **Western Australia**
Department of **Fisheries**

Water quality and disease

One of the most common causes of disease and mortality in land-based aquaculture is problems with water quality. Water quality has a direct effect on the health of aquatic animals. Some of the key factors affecting water quality are temperature, dissolved oxygen, pH, salinity, suspended solids, toxic waste levels such as ammonia and flow rates.

It is important that all aspects of water quality are monitored by the farmer, records kept on a daily basis and the factors associated with healthy water are adjusted if necessary to ensure they fall within acceptable ranges.

Water quality standards for finfish

Water variants	Acceptable levels for fish culture	Levels in water where fish kills have occurred
Oxygen	>6ppm, up to 100%	<3ppm, >100% sat.
Carbon dioxide	1.5 - 3.0 ppm	>15ppm
pH	6.7 – 8.6	<4 - 5, >9 - 10
Ammonia (unionised)	<0.02 ppm	>0.2 - 1.0 ppm
Nitrate	<1.0 ppm	>100 ppm
Nitrite	<0.1 ppm	>2.0 ppm (fresh)
		>20 ppm (salt)
Total hardness	20 – 200 ppm	>200 ppm (CO_2 excess)
Salinity		>800 ppm (all causes)
Total suspended solids	<80 ppm	>5,000 - 100,000 ppm
Total dissolved solids	<400 ppm	>5,000 – 20,00 ppm
Hydrogen sulphide	<0.002 ppm	>0.5 - 10 ppm

Published: March 2005 | Last updated: April 2012

Heavy metals

Water variants	Acceptable levels for fish culture	Levels in water where fish kills have occurred
Aluminium	–	>0.1 - 5 ppm (low pH)
Cadmium	<0.005 ppm soft water	>3 ppm
	<0.003 ppm hard water	
Copper	<0.006 ppm	>0.5 ppm
Mercury	<0.0002 ppm	>0.15 ppm
Lead	<0.02 ppm	>1 - 5 ppm
Zinc	<0.005 ppm	>0.5 - 1.0 ppm

Pollutants/organochlorine pesticides

Endrin	<0.003ppb	>0.0003 - 0.002 ppm
Endosulphan	<0.01 ppb	>0.01 ppm
Aldrin	<0.01 ppb	>0.013 - 0.05 ppm
Dieldrin	<0.005 ppb	>0.01 - 0.07ppm
Chlordane	<0.004 ppb	>0.02 - 0.08 ppm
DDT	<0.003 ppb	>0.008 - 0.027ppm

Organophosphate pesticides

Diazinon	<0.002 ppb	>0.2 - 5.2 ppm
Malathion	<0.008 ppm	>0.1 - 30 ppm
Trichlorphon	<0.001 ppb	>0.8 - 100 ppm
Pyrethrin insecticides	<0.001ppb	>0.0005 - 0.001 ppm
Rotenone piscicides	0.5 - 4ppm (16 - 22°C)	

Published: March 2005 | Last updated: April 2012

Algicides/herbicides

Water variants	Acceptable levels for fish culture	Levels in water where fish kills have occurred
Chlorine	<0.003 ppm	>0.1 - 4.0 ppm
Copper sulphate	<0.002 (max)	>0.14 ppm
Glyphosate (Round-up)	-	>10 - 130 ppm
Lime (CaO, $Ca(OH)_2$)	-	causing pH >9 - 10
2,4-D	<0.004	>2.0 - 100 ppm
Simazine	<0.01ppm	>10 ppm
Diesel oils, car oils	-	>50 - 100 ppm
Nicotine	-	>1 ppm
Detergents	<0.1 ppm	>4.0 ppm

(ppt = parts per thousand)
(ppm = parts per million)
(ppb = parts per billion)

The principles of biological filtration

Biological filtration is an essential requirement of any recirculating fish holding facility. Its primary function is to break down toxins excreted by fish.

Ammonia is a dissolved toxin released by fish metabolism which then breaks down to form nitrite. Both ammonia and nitrite are toxic to fish. Biofilters are designed to remove these compounds from the water by using nitrifying bacteria.

One group of bacteria, *Nitrosomonas*, can convert ammonia to nitrite, and another group, the *Nitrobacter* bacteria, can convert nitrite to the relatively non-toxic compound, nitrate (see the table ‘Water quality standards for finfish’ for acceptable levels).

Most biofilters have substrates made of coarse gravel shell or sponge, which provide a large surface area. The substrate is impregnated, either naturally or artificially, with nitrifying bacteria and the water is passed through the substrate, where the ammonia and nitrite are broken down by the bacteria.

To gain maximum efficiency there are several points to remember when setting up a biological filtration system:

- The filter bed requires several weeks of conditioning, using a small number of animals in the tank, to introduce the necessary bacteria. If this is not done, the inoculation of commercially available bacterial preparations will be required.
- In order to operate efficiently, the biofilter requires oxygen. The breakdown of ammonia stops if the dissolved oxygen level falls below 2mg O_2/L, so it is vital that the water entering the biofilter is as close to oxygen saturation as possible.

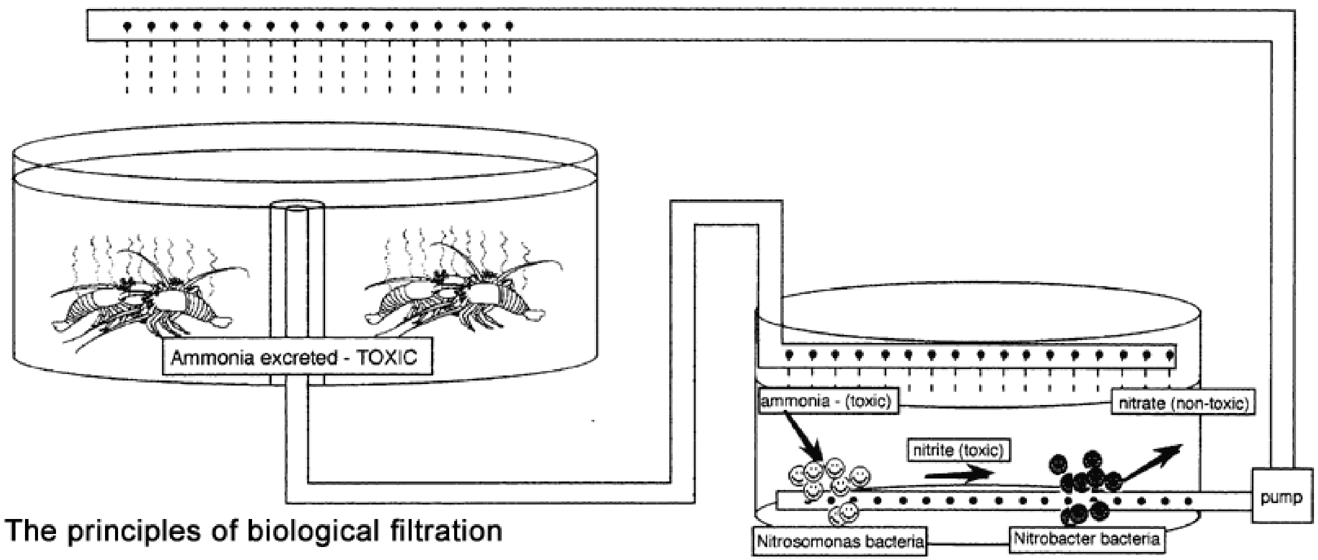
- Optimal temperature for the bacteria is 28°C - 36°C, although they will operate quite effectively at lower temperatures. They will, however die at 58°C and stop growing in any biofilter held below 12°C.
- The optimum pH for the bacteria is 8. However, in cases where ammonia levels have become dangerously high, the toxicity is reduced if the pH is dropped to 6. It is therefore necessary to maintain a balance between these two factors.
- To maximise the bacterial efficiency, the substrate must be evenly covered with the flow of water.
- Biofilters should not be shock loaded (i.e. a large number of animals placed in the system at one time, excreting a large volume of waste products). The amount of bacteria established in the filter will only operate efficiently for the previously established stocking density. If more animals are required to be added to the system, they should be introduced gradually to give the bacteria time to multiply.

If large volumes of solids are being produced, it may be necessary to install a sedimentation tank. This will remove any solid particles from the water before it enters the biofilter. These tanks are designed to allow a slow water flow, which enables the solid particles to settle on the bottom where they are tapped or siphoned out of the system.

It should be noted that in situations where shock loading occurs such as crayfish purging tanks, biological filtration can be very hard to manage and if the water is available, a flow-through system is recommended.

Published: March 2005 | Last updated: April 2012

Government of **Western Australia**
Department of **Fisheries**



The principles of biological filtration

A typical crayfish purging tank connected to a biological filter