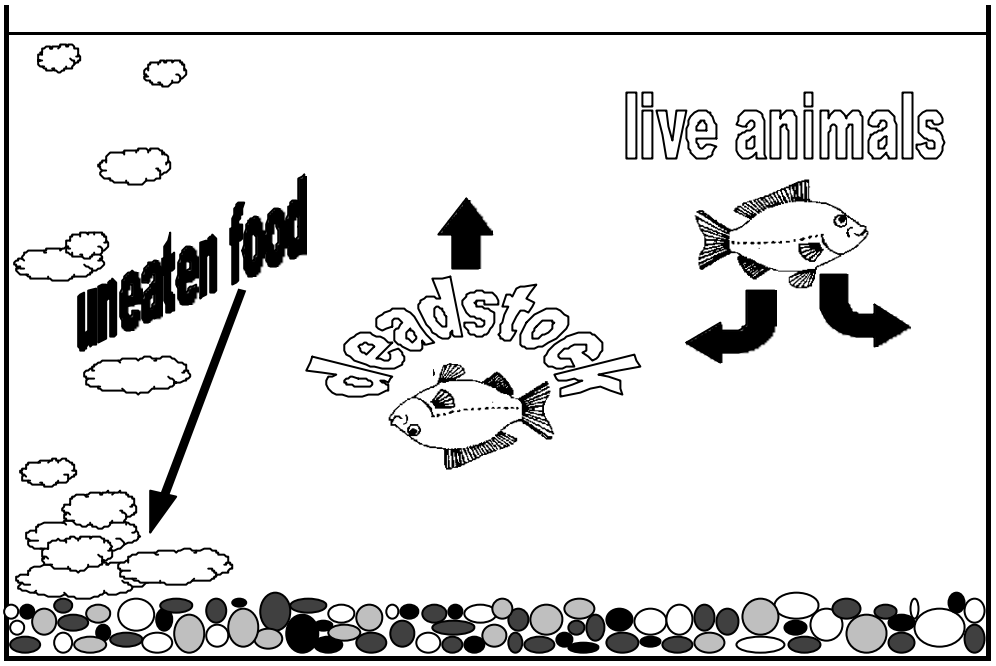

**ORNAMENTAL AQUATIC TRADE ASSOCIATION (OATA)**

# WATER QUALITY CRITERIA

# CONTENTS

# 1. AMMONIA

## SOURCES




| Table 1: Levels of TOTAL AMMONIA (mg/l or ppm) that maintain FREE AMMONIA at or below 0.02mg/l (ppm) at a range of pH and temperatures. | | | | | | | |
|---|---|---|---|---|---|---|---|
| pH/Temp C | 6 | 6.5 | 7 | 7.5 | 8 | 8.5 | 9 |
| 0 | 250 | 77 | 24 | 7.7 | 2.4 | 0.78 | 0.1 |
| 5 | 154 | 50 | 16 | 5 | 1.6 | 0.52 | 0.07 |
| 10 | 105 | 34 | 11 | 3.4 | 1.1 | 0.36 | 0.05 |
| 15 | 74 | 23 | 7.5 | 2.3 | 0.75 | 0.25 | 0.04 |
| 20 | 50 | 16 | 5 | 1.6 | 0.52 | 0.18 | 0.04 |
| 25 | 35 | 11 | 3.5 | 1.1 | 0.37 | 0.13 | 0.03 |
| 30 | 25 | 8 | 2.5 | 0.8 | 0.27 | 0.1 | 0.03 |

These figures apply to freshwater. To meet criteria for marine fish these figures should be halved.

Levels can be reduced by:

- improvement of stocking, feeding and general husbandry procedures
- improvement of biological filtration
- use of ion exchange materials
- dilution by water changes

In aquaria and ponds the principal sources of ammonia are:

- excretion by fish and other livestock as a normal part of their metabolism;
- the breakdown of protein in uneaten food or dead livestock which remains undetected. It is therefore of great importance that careful cleaning is undertaken at suitable intervals.

As ammonia is released into the water by either of these processes it may take one of two forms:

a) Free Ammonia (unionised ammonia, chemical symbol $NH_3$). This form of ammonia is highly toxic to fish
b) Ammonium (ionised ammonia, chemical symbol $NH_4^+$). This form of ammonia is virtually non toxic to fish

| | | | | |
|---|---|---|---|---|
| NH3<br>Total ammonia | dissolves | NH4 +<br>Free ammonia | + | NH3<br>Ammonium |

The balance between Free Ammonia and Ammonium is determined by the pH and temperature of the water and may be summarised:

| | |
|---|---|
| high temperature | high free ammonia |
| high pH | (low ammonium) |
| dangerous to fish | |

| | |
|---|---|
| low temperature | low free ammonia |
| low pH | (high ammonium) |
| relatively safe for fish | |

## MEASUREMENT OF AMMONIA

Test kits and electronic meters usually measure all ammonia present, this is TOTAL AMMONIA. (Some test kits measure Ammonium-Nitrogen and apply a conversion factor to determine the ammonia). This will usually be explained in the instructions provided with the test kit).

TOTAL AMMONIA = Free Ammonia + Ammonium

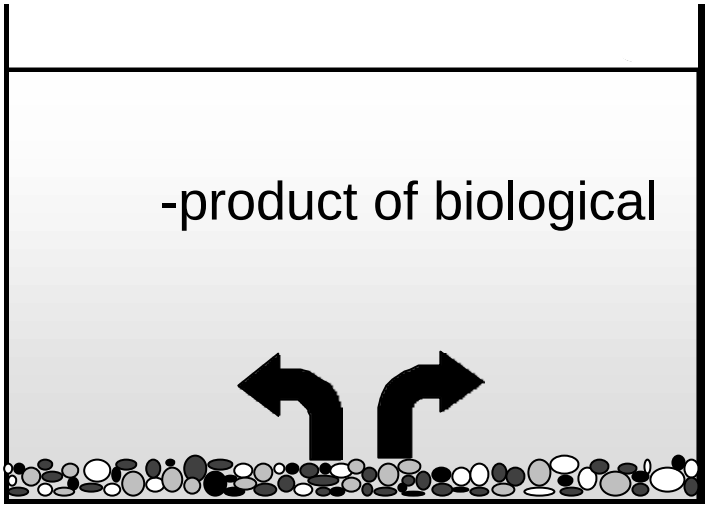
## SAFE LEVELS OF FREE AMMONIA

OATA recommends that FREE AMMONIA should not exceed 0.02ppm (mg/l) in freshwater and 0.01ppm in seawater.

Above this level free ammonia causes the fish stress and at higher levels it may cause damage to gills and many internal organs eventually resulting in fish deaths.

# 2. NITRITE

## SOURCES




Levels can be reduced by:

a) improvement of stocking, feeding and general husbandry procedures;
b) improvement of biological filtration;
c) dilution by water change;

In aquaria and ponds nitrites are produced by Nitrosomonas bacteria when ammonia is broken down.

## MEASUREMENT OF NITRITE

Test kits are available. (Some of these measure Nitrite-Nitrogen a conversion factor being applied to the result to obtain a true Nitrite reading; full instructions should be available with the test kit used).

## SAFE LEVELS OF NITRITE

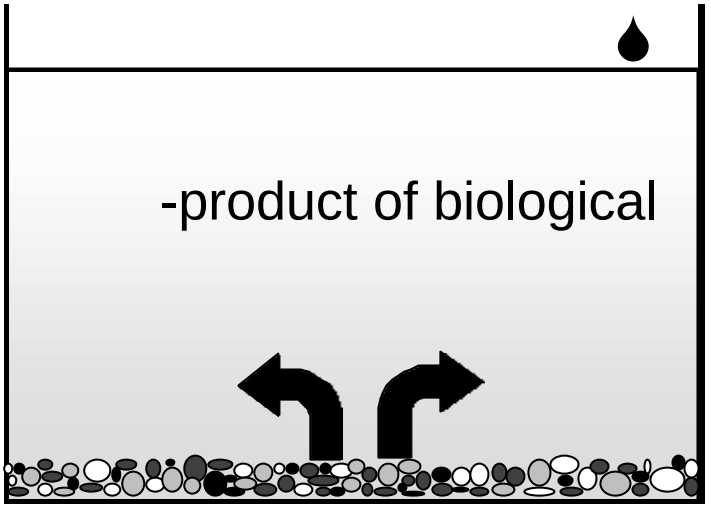
OATA recommends that Nitrite should not exceed 0.2mg/l in freshwater and 0.125mg/l in seawater.

Nitrite poisons the fish by binding to the haemoglobin in the blood preventing it carrying oxygen, in effect suffocating the fish. The gills of fish dying as a result of nitrite poisoning are a characteristic brown colour.

In freshwater the toxicity of nitrite may be reduced by the addition of small amounts of certain salts.

# 3. NITRATE

## SOURCES




Levels can be reduced by:

a) dilution by water change, (ensure water used for change has a lower nitrate level);
b) use of ion exchange materials;
c) increase plant density;
d) use of denitrifying biological filtration.

Nitrates are:

a) produced as Nitrobacter breaks down nitrites;
b) introduced in tapwater. (In some areas of the country in tapwater nitrate levels exceed 130mg/l)

## MEASUREMENT OF NITRATE

Test kits are available. (Some measure Nitrate-Nitrogen a conversion factor then being applied to obtain a true Nitrate reading; full instructions should be available with the kits used).

## SAFE LEVELS OF NITRATE

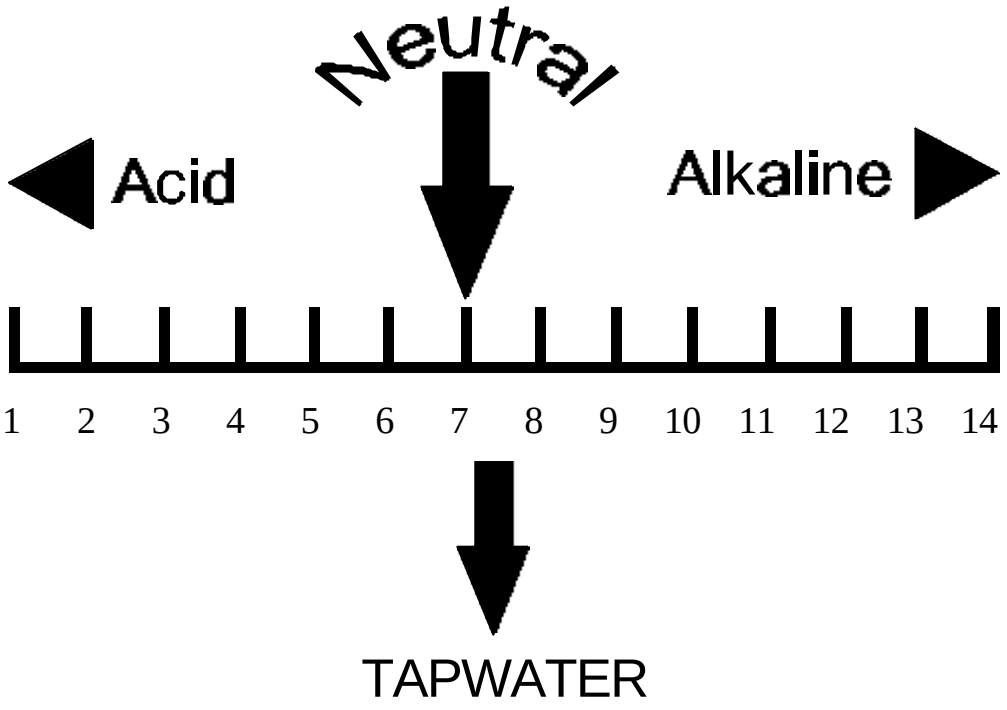
Nitrate is generally of low toxicity though some species, especially marines, are sensitive to its presence. When nitrate levels are high, as a result of biological filtration, other toxic chemicals produced in this process may be present at levels that adversely affect fish health.

In the 'Water Quality Criteria', OATA recommends that nitrate levels in freshwater ponds do not exceed those in the tapwater supply be 50mg/l.

As the livestock is more sensitive in marine systems Nitrate should not exceed 40mg/l.pH

# 4. PH

## THE PH SCALE...




This means that the ph of a pond or aquaria alters by one unit its acidity or alkalinity alters by ×10;

thus ph6 is ×10 more acid than ph 7,

and ph5 is ×100 more acid than ph 7.

# 5. BUFFERING

Hardwater and Seawater contain dissolved materials that prevent rapid changes in pH - they are BUFFERED.

The buffering system in seawater is overcome at about pH 8.1. Once the buffering system runs out a very rapid fall in the pH may occur jeopardising livestock.

## RISING PH

At low pHs the toxicity of ammonia is low. Low pHs may be brought about by carbon dioxide, produced by animals all the time and by plants at night, dissolving in water and forming carbonic acid.

If water of a higher pH is added, particularly if buffered, then there may be a sudden increase ride in pH. Associated with this rise will be a rapid increase in the toxicity of any ammonia present. This situation may arise in the transport of livestock in either hard, or sea-water.

# 6. DISSOLVED OXYGEN

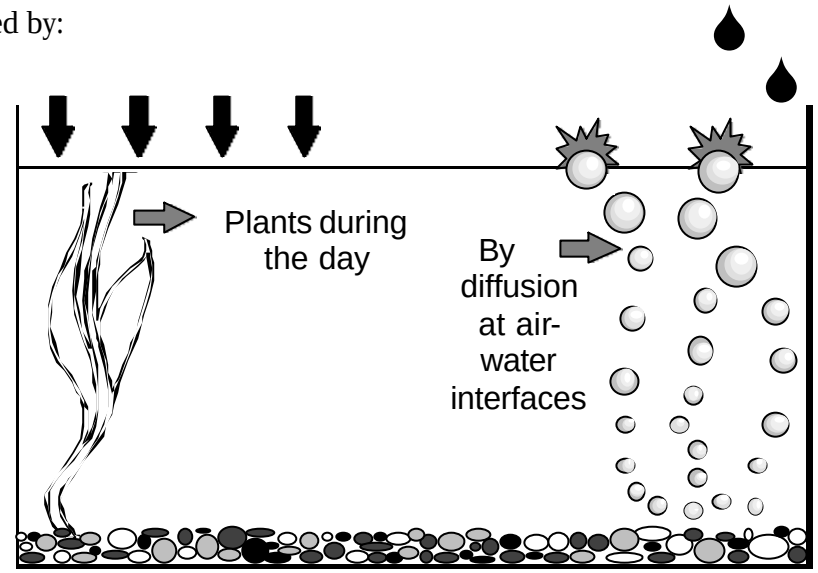
1 litre of oxygen weighs 1,428mg.

1 litre of air contains 285mg oxygen.

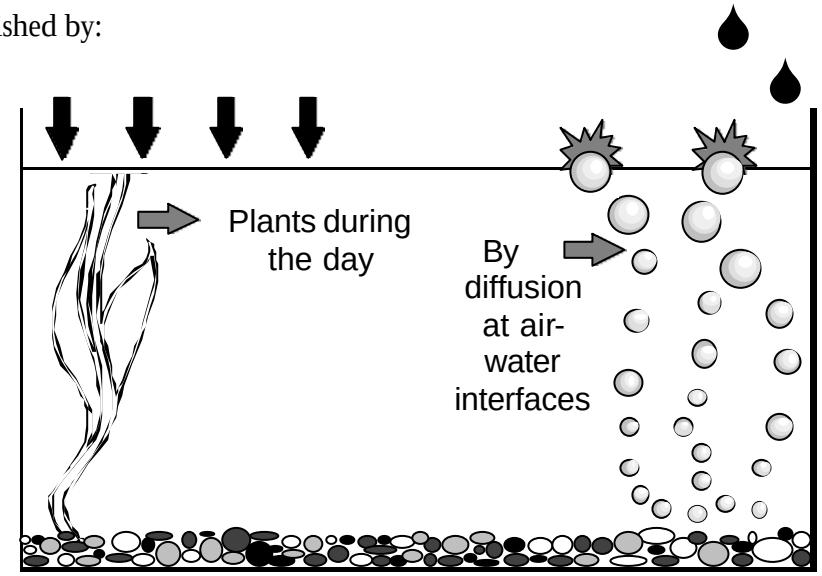
1 litre of freshwater contains 14.6mg oxygen at 0°C

Water is therefore an oxygen poor environment. It contains only 5% of the oxygen that the same volume of air does.

Oxygen is depleted by:




Oxygen is replenished by:



## SATURATION

If a beaker of sterile freshwater is left to stand at 25°C then the normal maximum amount of oxygen that it can dissolve is 8.2mg/l. At this point the water sample is said to be SATURATED. If it contained only 4.1mg/l then it would be 50% saturated. A level of dissolved oxygen of 6mg/l as recommended in the OATA 'Water quality Criteria' is equivalent to 73% saturation.

## SOLUBILITY OF OXYGEN

As the table below demonstrates, that as the water temperature rises the amount of oxygen it may dissolve before becoming saturated diminishes.

Seawater dissolves less oxygen than freshwater before it becomes saturated.

Table 2: Solubility of oxygen

| Temp C | mg/l oxygen freshwater | OATA criteria in terms of % saturation | mg/l oxygen saltwater | OATA criteria in terms of % saturation |
|---|---|---|---|---|
| 0 | 14.6 | 41 | 11.7 | 47 |
| 5 | 12.8 | 47 | 10.4 | 52 |
| 10 | 11.3 | 53 | 9.3 | 58 |
| 15 | 10.1 | 59 | 8.5 | 65 |
| 20 | 9.1 | 66 | 7.8 | 71 |
| 25 | 8.2 | 73 | 7.1 | 77 |
| 30 | 7.5 | 80 | 6.5 | 85 |

Altitude and atmospheric pressure play a small part in determining oxygen solubility. For practical purposes both may be ignored.

## WEATHER

The weather may combine all of the factors to create problems (some of them may arise also in fish houses).

Sunlight increases water temperature and hence decreases oxygen solubility.

Freezing-ice seals the surface preventing the entry of oxygen and the escape of toxic gases.

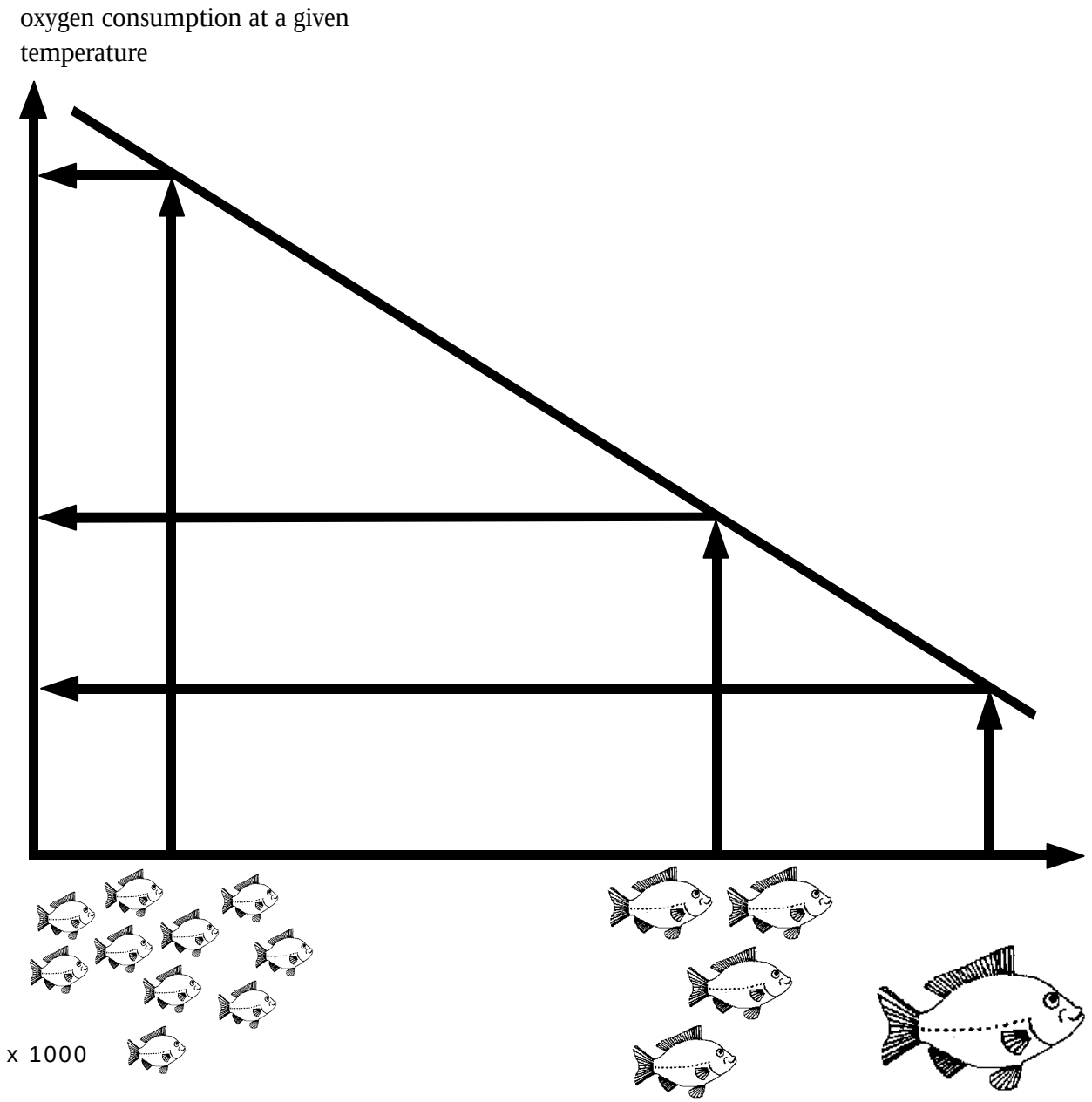
Still periods - when there is little wind such as before thunder storms, the rate of diffusion of oxygen is diminished by the reduction of the pond surface area (ripples in a light wind may increase the surface area of a pond by two or three times).

## MEASUREMENT OF DISSOLVED OXYGEN

Chemical test kits are available.

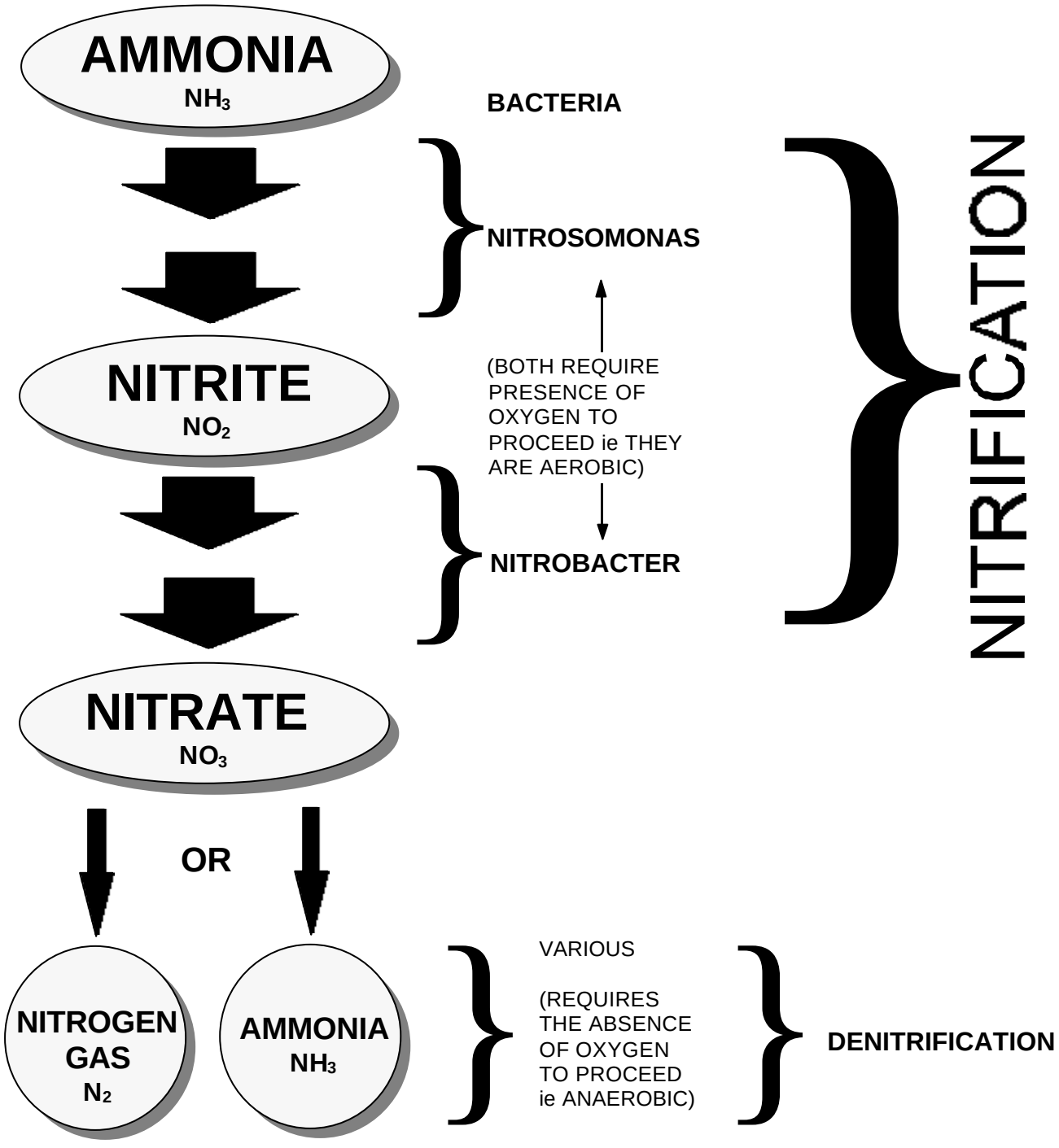
# OXYGEN CONSUMPTION

a) Size of livestock - small fish use relatively more oxygen than large fish.
b) Total weight of livestock.
c) Oxygen consumption of livestock doubles for each 10°c rise in temperature. (But oxygen availability is reduced as its solubility is also reduced by the temperature rise).
d) Biofilter activity ammonia production mirrors oxygen consumption.



# 7. BIOLOGICAL FILTRATION

Biological filtration is the process by which waste, principally ammonia, products in ponds and aquaria are broken down by bacteria.



The bacteria which are responsible for nitrification require:

a) a surface on which to grow (the larger the surface area, the greater the population which may grow)
b) a good supply of dissolved oxygen and an active filter may use more oxygen than the livestock in the water it processes
c) a supply of nutrients - ammonia and nitrites

The bacteria responsible for denitrification require:

a) a surface on which to grow;
b) a supply of nutrients;
    - principally nitrates;
    - and secondarily, if methanol of similar chemical is present, nitrogen gas will be formed;
    - if other organic materials are present, ammonia may be formed.

Oxygen kills the bacteria responsible for this process.

A filter may be said to be mature when any ammonia entering a tank is instantaneously converted to nitrite and then in turn to nitrate.

Biological filters are only mature for specific conditions; if the stocking density or feeding increases then the filter needs a further period of maturation.

# 8. APPENDIX A

## STOCKING DENSITIES - ORNAMENTAL FISH

It is virtually impossible to determine the quality of fish to be kept in a system purely on weight or number of fish per unit volume or area of water surface area.

The variation in holding system used, the quality of husbandry and types of fish stocked vary so greatly that it would render any such system too complicated to be practical; or too simple to be useful.

The maintenance of water quality standards can be used to determine working stocking densities.

## WATER QUALITY CRITERIA

### Cold Water Species

| | |
|---|---|
| * Dissolved Oxygen | - min 6mg/litre |
| * Free Ammonia | - max 0.02mg/litre |
| Nitrite | - max 0.2mg/litre |
| Nitrate | - max 50mg/litre above ambient tapwater |

### Tropical Species

| | |
|---|---|
| * Dissolved Oxygen | - min 6mg/litre |
| * Free Ammonia | - max 0.02mg/litre |
| Nitrite | - max 0.2mg/litre |
| Nitrate | - max 50mg/litre above ambient tapwater |

### Tropical Marine Species

| | |
|---|---|
| * Dissolved Oxygen | - min 5.5mg/litre |
| * Free Ammonia | - max 0.01mg/litre |
| Nitrite | - max 0.125mg/litre |
| Nitrate | - max 40mg/litre absolute |
| *pH | - min 8.1 |

Factors marked, *, should be measured in the first instance, if they prove satisfactory, and the fish appear healthy, then further investigation may not be necessary.

### Fish Under Treatment

It may not be possible to maintain levels given when effective disease treatments are in use.

# GUIDE STOCKING DENSITIES

The water quality standards should not be met at the expense of a correct feeding regime

## Cold Freshwater

8 kg/1000 l

## Tropical Freshwater

Fish up to 5cm (2") - 1.5 kg/1000 l
Fish over 5cm (2") - 2-5 kg/1000 l

## Tropical Marine

Fish up to 5cm (2") - 1 kg/1000 l
Fish over 5cm (2") - 2 kg/1000 l

Guides stockings are ADVISORY only. They may be exceeded if the water quality standards are satisfied. When the water quality standards are exceeded at a lower stocking, this must be considered as the maximum stocking density permissible.

The TOTAL volume of the system must be measured and taken into account in determining actual stocking densities.

## Technical Note

The above figures should be read in the following manner:
Free Ammonia as $NH_3$
Nitrite as $NO_2$
Nitrate as $NO_3$