7. WATER QUALITY MANAGEMENT FOR FISH FARMING

Introduction

Fish live, breed and grow in water. They are wholly dependent on water where they live. For fish, water quality is therefore the most important factor affecting their health and performance. Fish farmers must therefore understand the water quality requirements of the fish they want to grow or are growing. Good water quality refers to what the fish wants and not what we think the fish wants. Farmers must understand that different fish species have different and specific range of water quality aspects (temperature, pH, oxygen concentration, salinity, hardness, etc.) within which they can survive, grow, reproduce and perform optimally. Within these **ranges**, each species has its own **optimum range** within which it performs best. It is therefore very important for fish producers to ensure that the physical and chemical conditions of the water remain, as much as possible, within the optimum range of the fish under culture all the time. Outside these optimum ranges, fish will exhibit poor growth, erratic behaviour, and disease symptoms or parasites infestations. Under extreme cases, or where the poor conditions remain for prolonged periods of time, fish mortality may occur.

Pond water contains two major groups of substances:

- Suspended particles made of non-living particles and very small plants and animals, the plankton.
- Dissolved substances made of gases, minerals and organic compounds;

The composition of pond water changes continuously, depending on climatic and seasonal changes, and on how a pond is used. It is the aim of good management to control this composition to yield the best conditions for the fish.

For producers to be able to maintain ideal pond water quality conditions, they must understand the physical and chemical components contributing to good or bad water quality.

Physical Aspects of Water Quality

Temperature

Fish assume the temperature of the water they live in and are referred to as "cold-blooded". Water temperature is therefore a very important physical factor for fish survival and growth. The water temperature and thus the body temperature of the fish, has an effect on level of activity, behaviour, feeding, growth, and reproduction of the fish. Each species has its tolerance limits and optimum range. When water temperatures are outside the optimum range, fish body temperature will either be too high or too low and fish growth will be affected or even the fish die.

Table 1: Tolerance limits and optimum temperature ranges for commonly cultured fish species of Kenya (Nile tilapia, African catfish, common carp and rainbow trout):

Fish species	**Lethal water temperature (^{0}C)**		**Optimum temperature (^{0}C) range for adults**	**Temperature range for spawning (^{0}C)**
	Lower	**Upper**		
Oreochromis nilotica (Nile tilapia)	12	38	27-30	22-32
Clarias gariepinus (African catfish)	-	-	25-27	20-30
Micropterus salmoides (Largemouth bass)	2	35	23-30	17-20
Cyprinus carpio (Common carp)	2	36	23-26 (25)	Above 18
Oncorhynchus mykiss (Rainbow trout)	Close to 0	22	15-17 (16)	4-18

Turbidity

Fine suspended solid particles lead to water turbidity. Turbid Water can be said to be "cloudy". Turbidity can result from suspended solids (clay) or plankton (living organisms in water).

Clay turbidity in pond water (muddy water) can be harmful to fish and limit pond productivity. Clay turbidity in pond can be controlled by:

- Treating affected ponds with animal manures at rates of 2.4 T/ha every three weeks or applying agricultural lime at the recommended rates to improve soil pH and water alkalinity
- Avoiding stocking species that stir up pond bottom mud e.g. the common carp
- Designing water supply system in a way that allow muddy water to sediment or diverted away from the ponds

Plankton are small often microscopic aquatic plants (phytoplankton) and animals (zooplankton) found suspended in the water column. Phytoplankton forms the base of the food chain while zooplankton forms the second link in the chain in aquatic systems such as ponds.

In addition to their role as food for fish in ponds, phytoplankton provides oxygen through photosynthesis during the day. This oxygen dissolves into the water (DO) and therefore becomes available to the fish in the ponds.

Low phytoplankton density in ponds means less food and DO for the fish. On the other hand, too much (algal boom) lead to minimised sunlight penetration causing algal deaths. Less phytoplankton and decomposing plankton also lead to less food and DO for the fish. Good water quality, in relation to plankton therefore means water with just the right bloom. Visibility in a pond with the right plankton density should be about 30 cm.

A simple method of measuring turbidity it to stretch one arm, and immerse it vertically into the water until the hand disappears from sight.

Note the water level along your arm:

- If it Is well below your elbow, plankton turbidity is very high;
- If it reaches to about your elbow, plankton turbidity is right;
- If it reaches well above your elbow, plankton turbidity is low.

Suspended fish wastes are generally not a problem in semi-intensive aquaculture but in intensive systems, especially recirculation systems, they may be a major cause of poor water quality:

NOTE:
- *1 kg of fish waste is produced per kg of fish produced*
- *Fish waste contribute up to 70% of the nitrogen load in the system*
- *Fish waste lead to build-up of ammonia and nitrite*
- *Fish waste lead to reduction in dissolved oxygen*

Chemical Aspects of Water Quality

This is reference to the following parameters:

- pH
- Alkalinity
- Hardness
- Dissolved gases—oxygen, carbon dioxide, nitrogen, ammonia
- Salinity
- Essential nutrients—Nitrogen (N), Phosphorous (P) and Potassium (K)

Soil pH and Acidity

Pond water may be ***acid, alkaline*** or ***neutral***. Depending on this, water will react in different ways with substances dissolved in it. It will also affect in different ways the plants and animals living in the water. The measure of the alkalinity or acidity of water is expressed by its ***pH value***. The pH value ranges from 0 to 14, with pH 7 indicating that the water is neutral. Values smaller than 7 indicate acidity while those greater than 7 indicate alkalinity.

Fish production can be greatly affected by excessively low or high pH. Extreme pH values can even kill your fish. The growth of natural food organisms may also be greatly reduced. The critical pH values vary according to the fish species, the size of individual fish and other environmental conditions. For example, fish are more susceptible to extreme pH during their reproductive seasons, and eggs and juveniles are more sensitive than adults.

Waters ranging in pH from 6.5 to 8.5 (at sunrise) are generally the most suitable for pond fish production. Most cultured fish will die in waters with pH below 4.5 and 11 and above.

Fish reproduction and general performance can be greatly affected at pH below 6.5 and above 8.5, while a pH below 4.5 and above 10 will cause fish death.

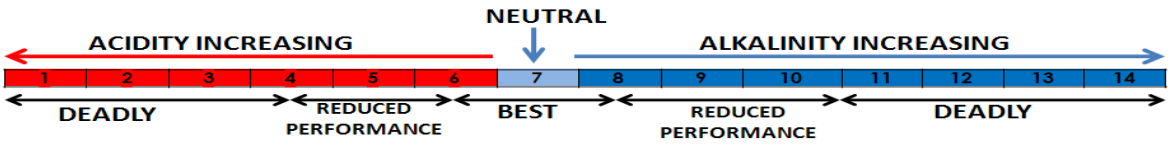


Figure 1: pH ranges showing tolerance limits and optimum range for fish

Pond water with pH unfavourable for fish production can be corrected as follows:

- ***pH is below 6.5 at sunrise:*** use lime and alkaline fertilizers
- ***pH is above 8.5 at sunrise:*** you can use acid fertilizers

Ensuring that soil pH and acidity are within acceptable limits is a necessary part of managing the alkalinity, hardness, and pH of the water, which were discussed above. The key is to keep soil pH at 6.5 or above, which will usually maintain water pH, hardness, and alkalinity at desirable levels. Soil pH can be kept at the right level by:

- Drying the pond for at least two weeks after each harvest before refilling and restocking.
- Applying lime (preferably agricultural limestone) to the pond after each harvest.

Normally lime should be applied to the pond bottom before it is refilled, but if necessary, it can be applied to the water surface after filling the pond. Only recommended liming materials and application rates should be used (***see pond farming of tilapia***)

Pond water pH varies over the course of a 24-hour day. This variation is related to the light intensity which is important in photosynthetic activity of phytoplankton.

- pH is lowest at sunrise and as the light intensity increases, photosynthesis increases causing more and more carbon dioxide to be removed from the water by the plants leading to rise in pH
- A peak pH value is reached in late afternoon.
- As the light intensity starts decreasing toward the evening there will be less photosynthesis and less carbon dioxide is removed from the water. Respiration adds more carbon dioxide to the water and the water pH starts to decrease.
- At sunset, photosynthesis stops, but respiration continues for the rest of the night. More and more carbon dioxide is produced, and pH keeps decreasing until sunrise, when it reaches its minimum.

Dissolved oxygen in fish ponds

The most important gas dissolved in water is oxygen (O2). Dissolved oxygen (DO) is essential for respiration and decomposition.

Dissolved Oxygen in water comes from atmospheric oxygen and photosynthesis.

The atmospheric oxygen diffuses and dissolves into the water. But the diffusion and its subsequent dissolving into water is a slow process. The major source of dissolved oxygen in ponds is photosynthesis. However this process depends on the amount of light available to the aquatic plants in water (Phytoplankton).

Therefore:

- Oxygen production decreases during cloudy days
- It stops at night
- It decreases in increase in water depth the rate of the decrease depends on the water turbidity

Measuring DO

DO can be measured by chemical or electrical methods.

Chemical methods rely on the use of kits which can be bought from shops dealing with laboratory equipment. They contain chemicals and equipment necessary to determine the DO content with sufficient accuracy for pond management purposes.

Electrical methods use an oxygen meter, this too can be bought from laboratory equipment shops but it is expensive. Using this equipment, DO can be measured directly from the pond at any depth.

DO and water temperature should be measured at the same time so as to be able to relate the DO to the temperature.

DO is expressed as mg of oxygen/litre of water (mg/l).

Table 2: DO requirements commonly farmed fishes in Kenya (in mg/l or percent saturation values)

Fish species	Ova and juveniles	Adults	
		Minimum DO level	Preferred DO level at least equal to
Trout	Close to 100%	5 mg/l (50%)	8 mg/l or 70%
Common carp	At least 70%	3 mg/l (30%)	5 mg/l or 50%
Tilapia	At least 70%	2 mg/l	4 mg/l or 50%
African catfish	At least 90%	1 mg/l or less (aerial respiration)	3 mg/l or 35%

Fluctuating oxygen levels

From sunrise to sunset

- *Photosynthesis increases the DO level*
- *DO production is higher in clear sky days than on cloudy days*
- *The higher the phytoplankton population, the higher the DO production.*

At night,

- *Photosynthesis does not take place*
- *Respiration and decomposition which are the main activities taking place, reduces the DO content until sunrise*
- *The higher the plankton population and dead matter, the faster the DO will fall*

There may be very little oxygen left by morning and fish may suffocate if corrective measures are not taken.

In over fertilised ponds, where there is very high plankton density and high turbidity, the bottom water may become anoxic (without oxygen) even during the day. The fish will concentrate at the surface of the pond to survive. This will be much worse at night.

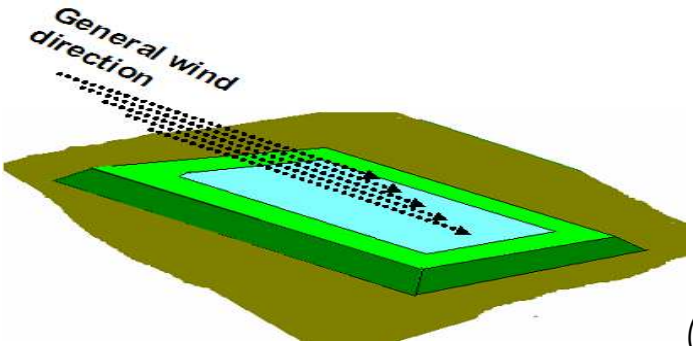
Where DO test equipments are not available, signs indicating reduced DO in pond water include:

- Fish not feeding well or even stopping feeding;
- Fish coming to the water surface to breathe from the better oxygenated surface water (this is called piping).

The DO content of pond water can be increased in several ways:

- Through design and management
- Through structures that cause water to splash e.g. by use of cascades along the inlet canal and raised inlet pipes before the water gets into the ponds
- By use of mechanical aerators for the emergency aeration of pond water

A simple way to ensure a good supply of atmospheric oxygen to fish ponds is in the design of the pond. The ponds should be designed such that they take maximum advantage of the winds. The ponds should be design such that the lengths are parallel to the direction of the important winds.



(Sketch by: Mbugua Mwangi)

Figure 2: Pond designed to take maximum advantage of the winds

Proper pond management can also improve the DO content of the water. The following measures can be taken before any emergency happens:

- Flashing the pond by removing the less oxygenated bottom water and replacing it with better oxygenated water
- Use of water aerators e.g. mushroom blowers or paddle wheels

Alkalinity and Hardness

It is desirable to maintain both alkalinity and hardness at 40-70 mg CaCO3/L. This can be done by:

- Where water is "soft" or acidic and soils are acid, apply lime (agricultural limestone) to the pond soil at recommended rates before to filling the pond
- Lime may also be added after filling by spreading it uniformly over the water surface.
- In areas where soils are alkaline and hardness and alkalinity are high, application of lime is not required.
- Note that proper management of hardness and alkalinity will usually eliminate the need to worry about pH.

(See pond farming of tilapia)

Ammonia

Un-ionized ammonia (NH3) concentrations in pond water should be kept below 0.5 mg/L. Concentrations of this form of ammonia, which is toxic to fish, are influenced by DO, pH, and alkalinity, therefore it is important to manage this by:

- Maintain water alkalinity at 40 mg CaCO3/L or above

- Keeping pH near neutral, and at least below 9.0
- Keeping DO concentrations high

Toxic Materials

Substances toxic to fish and other organisms (herbicides, insecticides, and other chemicals) should be kept out of the ponds. Ponds should be protected by:

- Not using insecticides, herbicides, or other chemicals (except for recommended inorganic fertilizers) in or near your pond
- Keeping agricultural runoff from the ponds
- Avoiding spraying agricultural crops or animals near ponds on windy days