IMPORTANT WATER QUALITY PARAMETERS IN AQUACULTURE

BY

Sambid Swain

Asst Professor and Head

School of Fisheries

Centurion University of Technology and Management

INTRODUCTION

Successful pond culture operations mainly depend on maintenance of a healthy aquatic environment and production of sufficient fish food organisms in ponds.

Physical, chemical and biological factors play an important role in governing the production of fish food organisms and fish production in the pond.

If the water quality is maintained with utmost care, the occurrence of many fish diseases can also be prevented.

A healthy water is a boon to fish culture

PHYSICAL FACTORS

Temperature

Temperature influence all metabolic and physiological activities and life processes such as feeding, reproduction, movement and distribution of aquatic organisms.

Temperature also affects the speed of chemical changes in soil and water. The oxygen content of water decreases with rise in temperature.

Most of the tropical fish cann't survive below 10^0C. Tilapia cann't survive below 8^0C.

Indian major carps are able to tolerate a wide range of temperature (20 to 37^0C), below 16^oC and above 40^0C prove fatal to them. Many exotic species can't survive at higher temperature.

- Fishes native to cold water (e.g. Silver Carp) are unable to survive on the plains due to higher water temperature in summer months.

- Both silver carp and grass carp prefers temperature below 30^{o} C. Hence, a knowledge of the range of temperature variation is necessary before introducing fishes for culture in a pond.

- Observation shown that instead of an annual turnover, as found in temperate climates, a daily turnover takes place in tropical ponds.

- During the nights, circulation takes place, bringing about a mixing of the water. This turnover is of extreme importance in the circulation of oxygen and nutrients in pond water.

Water Depth

Depth determines the temperature, circulation pattern of water and the extent of photosynthetic activity.

In shallow ponds, sunlight penetrates up to the pond bottom and facilitates an increase in the productivity.

A depth of 1-2 meters is considered optimal for biological productivity of a pond. If the depth is very less, water gets overheated and thus has an adverse effect on the survival of the fish.

In arid and semi-arid areas, water depth should be more than 2 meters.

The excess water from pond can be removed through pumping or through the use of outlet in the embankment.

If the water depth is reduced then from a nearby source it should be filling up.

Turbidity (Transparency)-1

$$\text{Transparency} \propto \frac{1}{\text{Turbidity}}$$

Turbidity of water ∝ The amount of suspended organic and inorganic matter.

- Turbidity and transparency both are optical properties of light
- Transparency cause light to be transmitted in straight line through the sample.
- while turbidity causes light to be scattered thereby restricts its penetration and reduce photosynthetic activity.
- Suspended particles causing turbidity may also adsorb considerable amount of nutrient elements like phosphate, K, N_2 in their ionic form and making them unavailable for plankton production,

- Turbidity due to profusion of plankton is an indication of pond's high fertility

- But that caused by silt or mud beyond a limit (up to 4% by volume) is harmful to fish and fish food organisms.

- Turbidity due to high concentration of silt, mud or algal growth causes death of fishes due to choking of gills.

- Suspended particles may be settled by application of lime

- Algal bloom can be restricted by application of alum in case of unicellular algae and copper sulphate in case of filamentous algae.

- If the pond water is covered by floating weeds, *Wolfia. sp (microweeds) or Lemna minor, Lemna major, Spirodella* for one week then also the algal growth is checked due to lack of penetration of sunlight.

Light

- Light is an important factor influencing productivity.
- Penetration of light depends upon the available intensity of the incident light, which varies with the geographical locations of the pond and turbidity of water.
- In shallow ponds, light reaches upto the bottom and causes heavy growth of vegetation.
- Light controls the flora and oxygen content of the water of the pond.
- Shade provided by the surrounding vegetation affects the incidence of light on the pond.
- Advantage of shading effect in often taken in pisciculture effect for the control of algal blooms and submerged weeds.

Water Colour

Water gets its colour due to phytoplankton, zooplankton, sand particles, organic particles and metallic ions in the pond water.

Water used for fish culture should be clear, either colourless or light green or blue in colour.

Water colour of golden or yellow brown indicates the abundant diatoms.

Water becomes greenish in colour when phytoplankton is more, develops a brown colour due to zooplankton and mud colour due to more sand grains.

Water with black, blackish green, dark brown, red, yellow colours are not good for culture. These colours are due to the presence of more phytoplankton, bad pond bottom and acids in the water.

The red colour of water is due to the presence of high levels of iron and death of phytoplankton (phytoerythrin released).

Biological characteristics

Biological characteristics of an aquaculture pond refers to the aquatic organisms that live within the pond. This includes both plants and animals.

The relationship between aquatic plants and animals is known as a trophic level or a food chain

Bacteria form the base of the food chain within an aquaculture pond.

Bacteria break down organic matter to produce nutrients such as phosphorus and nitrogen, and carbon dioxide (CO_2).

These products are then utilised by phytoplankton, microscopic algae, to produce oxygen via photosynthesis.

Oxygen and phytoplankton are then consumed by zooplankton which are tiny aquatic organisms.

Fish then feed on zooplankton as well as larger aquatic plants and supplementary feed that may be added to the aquaculture ponds.

Uneaten supplementary feed, dead aquatic organisms (including planktonic organisms and aquaculture species) and animal wastes will settle on the pond floor.

Bacteria will feed on this decaying organic matter and the cycle will commence again.

Fig 2: Trophic levels within an aquaculture pond.

CHEMICAL FACTORS

Dissolved Oxygen

Sources of Oxygen (O_2):

Absorption from air at the water surface.

Photosynthesis of chlorophyll bearing organism inhabiting pond.

Consumption of Oxygen (O_2):

Respiration of aquatic animals and plants in day and night.

Decomposition of organic matter

Value of dissolved O_2 depends on temperature, partial pressure of O_2 and water salinity, photosynthetic activity.

When temperature increases dissolved O_2 decreases.

When partial pressure of O_2 in contact with water at the surface increases amount of O_2 dissolved in water is also increases.

When concentrated of dissolved salts (salinity) increases dissolved O_2 concentration decreases. At 0^0C, fresh water contains slightly over 2.0 mg/l O_2 than sea water (35% salinity).

Since O_2 is a byproduct of the photosynthesis, it increases with increase in the rate of photosynthesis.

To Mitigate the oxygen deficiency

Direct ways or **Physical Methods** :

Beating by stick on all sides of ponds; Use Aerator
Introduce fresh oxygenated water from other areas to pond.
Pumping of water by water pump

Chemical methods:

i) Apply lime @ 60 – 70 Kg/ha.

ii) Apply KMnO4 @ 4 Kg/ha

iii) Use UltaSil-Aqua (Aqua Zeolite) of Neospark, Drugs and Chemical Private Ltd, Hyderabad @ 10 to 40 Kg per acre.

iv) Use Aqua Clean of G M Chemicals, Ahmedabd @ 25 – 35 Kg per acre at every 20-25 days.

Oxygen deficiency in lakes and river cause migration of fish, attack of parasites, fungus diseases and death due to suffocation.

pH levels

The pH is the measure of the hydrogen ion (H+) concentration in soil or water.

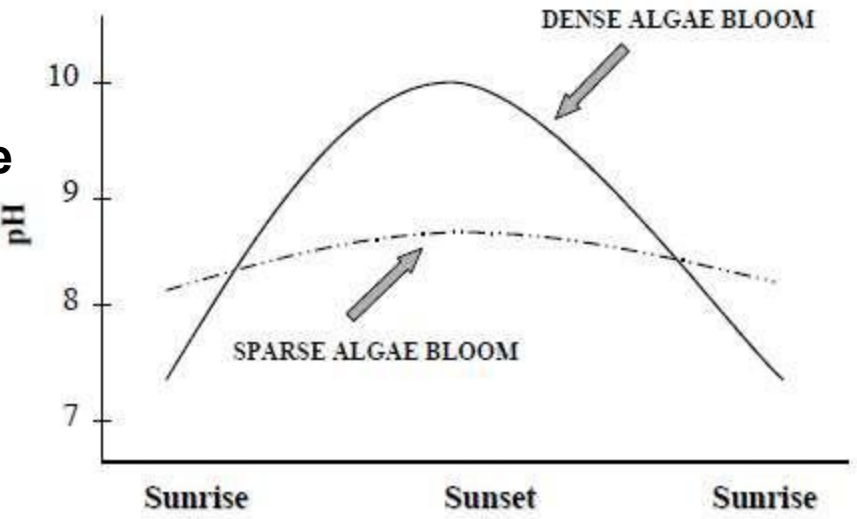
The pH scale ranges from 0 to 14 with a pH of 7 being neutral. A pH below 7 is acidic and an pH of above 7 is basic. A favorable pH range is between 6.5 and 9 (optimum 7.5-8.5)however this will alter slightly depending on the culture species

The pH in ponds will rise during the day as phytoplankton and other aquatic plants remove CO2 from the water during photosynthesis.

The pH decreases at night because of respiration and production of CO2 by all organisms.

Signs of sub-optimal pH include increase mucus on the gill surfaces of fish, damage to the eye lens, abnormal swimming behavior, fin fray, poor phytoplankton and zooplankton growth and can even cause death.

Fig: Diurnal fluctuations of pH will occur due to the amount of aquatic life within a pond. With higher algae concentrations, more CO_2 is removed from the system and hence pH levels will rise. The reverse will occur at night when more CO_2 is produced therefore leading to a drop in pH levels.



Free CO_2

Sources of CO_2 in natural water

i) From atmosphere:

Through rain water contains 0.3 – 0.6 ppm.

Air in contact with water surface.

ii) Respiration of aquatic plants and animals .

iii) Decomposition of organic matter in water body.

Consumption of CO_2

Photosynthesis by aquatic plants and phytoplankton for production of carbohydrates.

Carbon dioxide is present in three forms bound CO_3^{--}, half bound HCO_3^- and free state CO_2. When CO_2 comes in contact with water, it produce carbonic acid

$$H_2O + CO_2 = H_2CO_3$$

which displays its weak acidic character through dissociation

$$H_2CO_3 = H^+ + HCO_3^- = 2H^+ + CO_3^{--}$$

Just before day-break, concentration of CO_2 is highest and water is therefore, most acidic.

It increases the acidity of water

Water alkalinity and hardness

Alkalinity refers to amount of carbonates and bicarbonates and hydroxides in the water and water hardness refers to the concentration of divalent metallic cations like calcium, magnesium, strontium in water.

As calcium and magnesium bond with carbonates and bicarbonates, alkalinity and water hardness are closely interrelated and produce similar measured levels.

Waters are often categorised according to degrees of hardness as follows:

0 – 75 mg/l soft

75 – 150 mg/l moderately hard

150 – 300 mg/l hard

over 300 mg/l very hard

It is recommended that alkalinity and hardness levels are maintained around 50 to 300 mg/l which provides a good buffering (stabilising) effect to pH swings that occur in ponds due to the respiration of aquatic flora and fauna

Ammonia

Ammonia in ponds is produced from the decomposition of organic wastes resulting in the breakdown of decaying organic matter such as algae, plants, animals and uneaten food.

Ammonia is present in two forms in water – as a gas NH3 or as the ammonium ion (NH4+).

Ammonia is toxic to culture animals in the gaseous form and can cause gill irritation and respiratory problems.

Ammonia levels will depend on the temperature of the pond's water and its pH. For example at a higher temperature and pH, a greater number of ammonium ions are converted into ammonia gas thus causes an increase in toxic ammonia levels within the freshwater pond.

If high levels are ammonia are present within the pond's water, a number of measures can be taken. These include:

reduce or stop feeding,

flush the pond with fresh water,

reduce the stocking density,

aerate the pond,

in emergencies – reduce the pH level.

PHOSPHORUS

Phosphorus is recognized to the most critical single factor in the maintenance of pond fertility.

It occurs in three forms:

1. The soluble inorganic phosphate phosphorus (PO_4)
2. Soluble organic phosphorus and
3. The particulate organic phosphorus occurring in plankton, detritus and sedimentation.

Out of these three forms, form PO_4 i.e. soluble inorganic phosphate phosphorus or dissolved phosphorus takes part in production.

It is required for cell division, preparation of fat, protein, high energy compounds (ATP, ADP, AMP) etc in the body.

If pond soil is acidic, phosphorus become unavailable and stays in compound form with Fe, Al, Mn, Zn,

For this reason, phosphate fertilizers are applied with lime in acidic soil.

But, if the condition is highly alkaline, the phosphate again remains in pond soil as a compound form with Ca and Mg.

Availability of phosphorus is highest near neutral pH.

Dissolved Solids

The total concentration of dissolved solids in a water body is a useful parameter in deserving chemical density as a fitness factor that contributes to the productivity of the water.

Electrical conductivity, which gives the total amount of ionized materials is an important measure of total dissolved solids present in water and is usually expressed as micromhos.

Electrical conductivity above 400 Mmhos does not limit productivity but productivity does not increase proportionately with conductivity.

Dissolved solids may be organic or inorganic.

Inorganic dissolved solids are: metallic ions (eg. Ca, Mg, Na, K, Fe) in combination with anions like Cl^-, SO_4^{-2}, CO_3^{-2}, HCO_3^-, OH^-, PO_4^{-3}, NO_3^-, NO_2^- etc. and there may be trace elements like Ni, Co, Mn, Zn, Cu, Cr, Al, Silica, etc.

Whereas, organic dissolved solids are: organic state of nitrogen, phosphorus and sugars, acids, fats, vitamin etc.

Optimum water quality requirement for a fish pond:

Sl. No.	Parameter	Fresh Water	Brakish Water	Sea Water
1	Colour	Clear water with greenish hue<100 color units	Clear water with greenish hue<100 color units	Clear water with greenish hue<100 color units
2	Transparency	20-35cm	26-35cm	26-35cm
3	Clay-turbidity	<30ppm	<30ppm	<30ppm
4	TDS(ppm)	<500	<500	<500
5	pH	6.7-9.5	7.0-8.7	7.0-8.5
6	TSS(ppm)	30-200	25-200	25-200
7	Hardness(pp	30-180	>50	>50

Sl.No	Parameter	Fresh water	Brakish water	Sea water
8	Alkalinity	50-300ppm	>50ppm	>50ppm
9	Chloride	31-50ppm	>500ppm	>500ppm
10	Salinity	<0.5 ppt	10-15ppt	>30ppt
11	D.O.	5-10ppm	5-10ppm	5-10ppm
12	Dissolved CO_2	<3ppm	<3ppm	<3ppm
13	Unionized NH_3	0-0.1ppm	0-0.1ppm	0-0.1ppm
14	Ionized NH_3	0-1.0ppm	0-1.0ppm	0-1.0ppm
15	NO_2-N	0-0.5ppm	0-0.5ppm	0-0.5ppm
16	NO_3-N	0.1-3 ppm	0.1-3 ppm	0.1-3ppm
17	BOD(Kg/ha/day)	150	100	75
18	COD ppm	<50	<70	<70
19	H_2S ppm	<0.002	<0.003	<0.003
20	Total Nitrogen	0.5-4.5ppm	0.5-4.5ppm	0.5-4.5ppm

CONCLUSION

Water quality varies considerably at different geographical locations.

Fish can use some water supplies considered impaired for human use, even some saline waters have aquaculture potential.

Water quality affects growth and well being of fish. Therefore, water quality should be of great importance to the aquaculture.

Water quality varies with time to time and therefore requires regular monitoring.

It is equally important to know how to interpret the water quality parameters that are measured to maintain the health and well being of their fish stock.

REFERENCES

https://www.barrier.ru/en/encyclopedia/about_water/mutnost_i_prozrachnost_vody

http://www.fao.org/docrep/t8598e/t8598e05.htm

SS Sagar, RP Chavan, CL Patil, DN Shinde, SS Kekane, Physico-chemical parameters for testing of waterA review, International Journal of Chemical Studies 2015; 3(4): 24-28.

Dr. Subhendu Datta, Management of water and soil for aquaculture

Tiwari, Dr.S, Water Quality Parameters –A Review, International Journal of Engineering Science Invention Research & Development; Vol. I Issue IX March 2015