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Management Practices of Soil and Water Quality Parameters in Aquaculture

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SUMMARY

Maintenance of a healthy aquatic environment and production of sufficient fish food organisms (plankton) in ponds are two factors of primary importance for successful aquaculture culture operation. Water quality parameter is an essential in fish farming practices as poor water quality parameters can affect the health and growth of the fish populations. Soil quality parameters is an essential factor in fish pond productivity as it controls the pond bottom stability, PH and salinity of overlying water and concentrations of plant nutrients required for the growth of phytoplankton, which is the best of food chain of the fish.

INTRODUCTION

The nutrient status of water and soil play the most important role in governing the production of plankton organisms or primary production in fish ponds. The bottom soil governs the storage and release of nutrients to the overlying water through various chemical and biochemical processes for biological production in the environment. Good bottom soil and water quality are vital ingredient for any successful aquaculture practices. Although such problems are related to site characteristics bottom soils have undesirable properties viz acid sulphate, high organic and excessive porosity etc. Similarly, the water may have poor quality, viz highly acidic, rich in nutrient and organic matter, high in suspended solids or polluted with industrial or agricultural chemicals**.**

Water Quality Management:

Fish being aquatic being are more prone to disease and are difficult to control. The equilibrium of disease, environment and fish health are important any change in the equilibrium leads to “stressed” and becomes vulnerable to disease which have influences on growth and survival.

Physical parameter:

The Physical condition of water is greatly influenced with depth, temperature, turbidity and light. These constitute the more important physical parameters on which the productivity of a pond depends.

Depth : Depth of a pond has an important bearing on the physical and chemical qualities of water. Depth determines the temperature, the circulation pattern of water and the extent of photosynthetic activity. In shallow ponds, sunlight penetrates up to the bottom, warms up the water and facilitates increase in productivity. Ponds shallower than 1m get overheated in tropical summers inhibiting the survival of fish and other organisms. Generally, a depth ofabout1.5- 2 meter is considered ideal from the point of view of biological productivity of a pond

Water temperature : Generally, depends upon climate, sunlight and depth. That too, the intensity and seasonal variations in temperature of a water body have a great bearing upon it productivity. The temperature in fish ponds is generally less during the early hours of morning and reaches the maximum value in the afternoon showing diurnal fluctuations. Compared to the yields of fish in ponds in temperate zones, the natural water in tropical areas generally show a higher production due to more heat budget in the ponds system. A part from these, temperature plays very important role in physiological processes for breeding in fish both under natural and artificial conditions. The chemical changes in both soil and water are greatly influenced by temperature. Decrease in DO is directly related to increase in temperature. Fish display great variability in their tolerance to temperature. Indian major carps usually tolerate wide range of temperature and are called eurythermal. Temperature sets the pace for metabolism and biochemical reaction rates. The optimum temperature range for cold water and warm water fishes are 14°C - 18°C and 24°C - 30°C respectively. Temperature can be adjusted to optimum level in controlled

condition like hatcheries but difficult to adjust in large water bodies. Operation of aerator helps in breaking thermal stratification while planting of trees gives shades.

Turbidity: May be either due to suspended inorganic substances like silt, clay and planktonic organisms. Turbidity of water varies greatly with the nature of basin and inflowing sediments. Ponds with clay bottom are likely to have high turbidity that restricts the penetration of light, therefore reduces the photosynthetic activity hence acts as a limiting factor for productivity. Several factors like suspended soil particle, planktonic organisms and organic matter contributes to turbidity. Measured using Secchi disc the optimum visibility ranges from 40-60 cm. it can be controlled by application of organic manure at 500-1000 kg/ha, gypsum @ 250-500 kg/ha or alum @25-50 kg/ha.

Light: Light is another physical factor of importance. Availability of light energy to a fish pond greatly influences its productivity. Penetration of light is determined by turbidity which is measured optically and represents the resultant effect of several factors such as suspended clay and silt and dispersion of planktonic masses.

Chemical parameter:

Hydrogen ion concentration (p^H)

The pH of water is defined as the logarithm of the reciprocal of hydrogen ion concentration. It may be expressed mathematically as $p^H = -\text{Log}\ (H^+)$. The p^H of neutral water is 7, below 7 is acidic and above 7 is alkaline. The p^H of pond water undergoes a diurnal change; it is being alkaline in mid-afternoon and acidic just before day break. High yield of fish crops are usually produced in water which is just on the alkaline side of between 7.0 and 8.0. The limit above or below which p^H has a harmful effect is given as 4.8 and 10.8. p^H is a measure of hydrogen ion concentration in water and indicate how much water is acidic or basic. Water p^H affects fish metabolism, physiological process, toxicity of ammonia, hydrogen sulphides and solubility of nutrient thereby well-being and fertility. p^H at the range of 6-8.5 is best for fish growth and can be increase by application of lime. Agriculture gypsum may be applied to correct alkaline p^H.

Alkalinity

Alkalinity combining capacity of natural freshwater ponds is generally caused by carbonate (CO_3) and Bicarbonate (HCO_3) or hydroxides of calcium, Magnesium, Na, K, NH_4^+ and Fe^{+2}, calcium being from the major constituent. Bicarbonate and carbonate are the major constituent of pond water and their concentrations are expressed as total alkalinity. In general, calcareous water with alkalinities more than 50ppm are most productive. Waters with an alkalinity less than 10ppm rarely produce large crops, water intermediate between these 10-50ppm may produce useful results. Ideal range from 60-300 ppm as $CaCO_3$ and it can be treated with lime. Less than 20 ppm leads to fluctuation and more than 300 ppm may become unproductive due to limitation of carbon dioxide availability.

Dissolved oxygen

Dissolved oxygen Among the chemical substances in natural water, O_2 is of primary importance both as a regulator of metabolic processes of plant and animal community and as an indicator of water condition. The pond water receives oxygen mainly through interaction of atmospheric air on the surface water by photosynthesis. Photosynthesis, respiration and slow rate of diffusion cause a fluctuation of dissolved oxygen in water and accordingly remain optimum during morning and gradually increase to attain maximum in the afternoon and declines thereafter during night to reach minimum before dawn. It is possible that below 3.0 ppm of DO, asphyxia from low O_2 can be expected and to maintain a favourable condition for a varied warm water fish fauna, 5.5 ppm of DO is required. Sometimes fishes congregate near the surface for respiration in such low DO ponds. For average or good production ponds should have DO concentration above 5.5 ppm. The optimum dissolved oxygen (DO) content of pond waters is in the range of 5ppm saturation level. Aeration is a proven technique for improving DO availability. Any sort of agitation improves the DO content and among which paddle-wheel, aerators aspirators are most common.

Hardness

Hardness is defined as the total of soluble Calcium and Magnesium salts present in the water medium. In most natural water, usually HCO_3 anions are associated with Ca, Mg, Na and K cations. Usually bicarbonates of Ca and Mg cause temporary hardness. Permanent hardness of water is due to soluble Ca and Mg carbonates and salts of inorganic acids ($CaSO_4$). The pond water having a hardness of 15 ppm or above are satisfactory for growth of fish and do not require addition of lime, but water having hardness, less than 1.1ppm require liming for higher production of fish. Water having, hardness less than 5 ppm, cause slow growth, distress and eventual death of fish. It should be greater than 40 ppm because it helps to protect fish against harmful effect of p^H and metal ions. Low hardness can be treated with lime.

Ammonia

Ammonia Fish are very sensitive to unionized ammonia (NH_3) and optimum range is 0.02-0.05 ppm in the pond water. The same is reduced in the case of high DO and high CO_2. Aeration, healthy phytoplankton population removes ammonia from water. Addition of salt @ 1200-1800 kg/ha reduces toxicity. Formalin are also use in certain cases. Biological filter may be used to treat water for converting ammonia to nitrate and then to harmless nitrate through nitrification process.

Dissolved Nitrogen and its compounds

The importance of dissolved nutrients especially nitrogen is well recognized. It is an important element influencing the growth of phytoplankton in aquatic environment. As constituent of protein, Nitrogen occupies a highly important place in aquatic ecosystem. Pond having dissolved nitrogen below 0.1ppm does not indicate productive condition, while the range of 0.1-0.2 ppm an average production is expected but above 0.2ppm is considered favourable. However optimal limit of nitrogen can be in the range of 0.3-1.3ppm.

Phosphorus

The phosphorus fertility less than 0.02ppm is low productive, 0.02-0.05 ppm is fairly productive, 0.05-0.10 ppm is good productive and above 0.20 ppm excessive. Besides the absolute concentration, the ratio of nitrogen and phosphorus concentration is likely to influence aquatic productivity. Nitrogen and phosphorus are utilized for plankton growth at a ratio of 3:1 to 6:1.

Hydrogen sulphide

Fresh water fish pond should be free from hydrogen sulphide because at concentration of 0.01 ppm fish lose their equilibrium. Frequent exchange and increase of p^H through liming can reduces its toxicity.

Carbon dioxide

Pond water should contain low concentration of free CO_2

Parameters	**Water quality Standard**
Depth	1.5-2 meters
Temperature	Cold water and warm water fishes are 14°C-18°C and 24°C-30°C.
Turbidity(NTU)	5.0
P^H	6.5-8.5
Alkalinity(mg/L)	50-250
Dissolved Oxygen(mg/L)	More than 4
Hardness(mg/L)	40-400
Ammonia	0-0.5ppm
Hydrogen Sulphide	0-0.01ppm
Nitrite(NO_2^-)	Less than 1 ppm

Bottom Soil Management:

Bottom soil is considered as the chemical laboratory of the pond. However, suitable soil quality problem is common in aquaculture, and therefore, many methods are used for purpose of improving pond soils.

Texture

The nature and the properties of the parent material forming the soil determine the soil texture. An ideal pond soil should not be too sandy to allow leaching of the nutrients or should not be too clayey to keep all the nutrients absorbed on to it. For sandy soil, heavy dose of raw or composed farmyard manure varies from 10000 to 15000 kg/ha/year is required.

Soil acidity

The soil may be acidic, alkaline or neutral but the ideal range for soil p^H is 6-8. Acid ponds do not respond well to fertilization and liming is the only way to improve water quality with acid soil and it is the soil that must be corrected for lasting effect, rather than the pH of the water.

Bottom soil oxidation

When the redox potential is low at the soil surface, hydrogen sulphide and other toxic microbial metabolites diffuse into the pond water. Sodium nitrate ($NaNO_3$) can serve as a source of oxygen for microbes in poorly oxygenated environment in which the redox-potential will not drop low enough for the formation of hydrogen sulphide and other toxic metabolites.

Drying pond bottom

Evaporation of water from soil pores and cracking of soil during drying enhances aeration and favour microbial decomposition of soil organic matter. Excessive drying makes soil too dry for microbial activity, so a period of 2-3 weeks is adequate. Tilling with a disk harrow also improves aeration but compaction is required before refilling to reduce erosion.

Sustainable Pond Productivity:

Nutrient removal

It is possible to precipitate phosphorus from pond water by applying sources of iron, aluminium or calcium ions. Alum (aluminium sulphate) or ferric chloride are commercially available of which the former is cheap and widely used. Alum @ 20-30 ppm is more suitable in alkaline water (>500 ppm) and gypsum (calcium sulphate) @ 100-200 ppm is better in low alkaline water.

Plankton removal

Copper sulphate @ 1/100 of the total alkalinity is recommended for reducing phytoplankton abundance and blue-green algae in particular.

Chlorination

It is possible to disinfect bottom of empty pond and waters in newly filled and unstocked ponds by applying chlorine products @ 1ppm or more of free chlorine residual. The residuals will detoxify naturally in a few days so that ponds can be stock safely.

Liming

Liming should be always done depending upon the p^H of the water and the soil. As the health of the soil determines the nature of the pond water, p^H of the water can be taken as reference to determine appropriate dose of application p^H Soil / Water condition Dose of lime (Kg/Ha).

p^H	Soil/Water Condition	Dose of Lime (Kg/Ha)
4.0-4.5	Highly Acidic	1000
4.5-5.5	Medium Acidic	700

5.5-6.5	Slightly Acidic	500
6.5-7.5	Near Neutral	200

Soil quality parameters:

Soil plays an important role in regard to the fertility of fish ponds. Types, characteristics and chemical conditions of soil influences the pond productivity. The physico-chemical properties of pond water are more or less a reflection of the properties of the bottom soil. In this respect the major chemical factors of importance are p^H, total nitrogen, total phosphorus, organic carbon, available N_2 and available P.

Hydrogen ion concentration (p^H)

The p^H of soil depends on various factors. The release of essential nutrients at soil water interface is greatly hampered due to low p^H. p^H range of 5.5 is (highly acidic) 5.5-6.5 (moderately acidic), 6.5-7.5 (nearly neutral) and 7.5-8.5 (moderately alkaline) has been considered favourable for fish ponds, whereas above 8.5 is considerable highly alkaline.

Phosphorus

he importance of available phosphorus in soil for increasing productivity is well recognized. The phosphorus in soil is in both inorganic and organic forms. The organic form constitutes about 35-40% of the total phosphorus content of the soil. The available soil phosphorus (P_2O_5) below 3 mg/100gm (30ppm) as poor productivity, 3-6mg/100gm (30-60ppm) as average, above 6-12mg/100gm (60-120ppm) as high productivity and above 12mg/100gm (120ppm) as excess.

Nitrogen

Nitrogen in soil is present mostly in organic forms as amino acids, peptides and easily decomposable proteins. The conversion of complex organic forms of nitrogen to simple inorganic forms is carried out by anaerobic microbes. Hence, it is important to know available nitrogen than the total nitrogen in soil. The range of available nitrogen is 50-75mg/100gm of soil relatively more favourable for pond productivity.

Organic carbon

Compared to the mineral constituents of the soil, organic compounds are more varied and complex. Very high organic content is also not desirable for a pond soil. However, organic carbon less than 0.5% may be considered poor, 0.5-1.5% as average while 1.5-2.5% appeared to be optimal for good production.

CONCLUSION

Water and soil quality parameters are very essential in fish farming practices as poor quality of water and soil can severely effect the health and growth of the fish populations. It is essential that the farmers pay attention to the soil and water factors. Good bottom soil and water quality are important ingredients for any successful aquaculture practices. Water is the medium in which all the aquatic organisms live and from which they derive oxygen and nutrients. So, the quantity and quality of the water very much affects the fish farming. Therefore, water is the basic part of the fish culture its specific properties as a culture medium are naturally great in the pond productivity.

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