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Subject: Water & Soil Quality Management in Aquaculture (Industrial Aquaculture and Fisheries) B.Voc. Skilled Component)

Semester – II

Introduction: 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.

Dissolved oxygen: The optimum dissolved oxygen (DO) content of pond waters is in the range of 5 ppm 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.

Temperature: Temperature sets the pace for metabolism and biochemical reaction rates. The optimum temperature range for cold water and warm water fishes are 140C-180C and 240300C 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: Several factors like suspended soil particle, planktonic organisms and organic matter contributes to turbidity. Measured using Secchi disc the optimum visibility range 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.

Ammonia: Fish are very sensitive to unionized ammonia (NH_3) and optimum range is 0.020.05 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.

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 pH through liming can reduces its toxicity.

pH: pH is a measure of hydrogen ion concentration in water and indicate how much water is acidic or basic. Water pH affects fish metabolism, physiological process, toxicity of ammonia, hydrogen sulphides and solubility of nutrient thereby well-being and fertility. pH at the range of 6-9 is best for fish growth and can be increase by application of lime. Agriculture gypsum may be applied to correct alkaline pH.

Total Alkalinity: Ideal range from 60-200 ppm as $CaCO_3$ and it can be treated with lime. Less than 20 ppm leads to fluctuation and more than 200 ppm may become unproductive due to limitation of carbon dioxide availability. Ideally 70-150 ppm is considered productive to aquaculture pond.

Total hardness: It should be greater than 40 ppm because it helps to protect fish against harmful effect of pH and metal ions. Low hardness can be treated with lime.

Carbon dioxide: Pond water should contain low concentration of free CO_2 (not greater than 10 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 pH 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 redoxpotential 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 sulpahte @ 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 pH of the water and the soil. As the health of the soil determines the nature of the pond water, pH of the water can be taken as reference to determine appropriate dose of application.

pH	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

Water Exchange: When stocking density increases, it is of primary importance to have a dependable water supply and to maintain good water quality. So far, besides aeration, water exchange is still the most effective and widely employed method to maintain good water quality besides water quality enhancers like sanitizers, zeolite etc. Generally, water exchange is used to adjust salinity as desired, to remove excess metabolites, to keep algae healthy and producing ample oxygen and to regulate pond water temperature. The exchange rate varies with the production period, stocking density and total biomass, levels of natural productivity, turbidity and source and volume of water. The principle of water exchange is to change the water in a way such that the water quality changes gradually instead of abruptly. In semiintensive systems, frequent and sometimes even continuous water exchange at a small flowing rate is employed. Abrupt addition of large quantities of water in small ponds may result in sudden environment change, which subsequently can stress in culture organism. Therefore, massive water replacement is not recommended unless there is sudden die-off of plankton, critical low oxygen or after the application of chemicals. Continuous water exchange should be accompanied with running of paddlewheels to have the pond water fully mixed. Otherwise, it will cause great differences of water quality within a pond and heterogeneous distribution of culture organisms on the pond bottom. Lowering the water level first and adding new water is not recommended, especially during daytime in summer. Increasing water temperature, while lowering water level, can reduce the capability of water to hold oxygen and hasten the degeneration of the pond bottom, leading to oxygen depletion. It is better to add new water first according to the predetermined exchange rate, have the paddlewheel running to homogenize water throughout the pond and then discharge water.

Water exchange is the first method to improve pond management, except when

1) Good quality of water is not available.
2) A drastic change to the pond environment should be avoided.
3) Culture organisms have been greatly weakened as a result of nutrition depletion 4) and diseases.
5) Ponds are being treated with chemicals and medicine.

While doing water exchange several parameters should be noticed such as pH value, salinity, temperature, turbidity and other parameters related to defining good pond environment.

Aeration: Paddlewheels are commonly used in semi-intensive shrimp/prawn culture and is one of the major capital cost items in the farm. The paddlewheel aerators are used to increase contact surface of water with air thereby increasing the area through which oxygen isabsorbed by the water and to create a circular movement of the pond water. This has the following advantages:

1) It increases the dissolved oxygen level of the water and prevents oxygen depletion during the night.
2) It accelerates the diffusion effect of not only the oxygen, but also enables the capture or release of carbon dioxide. Carbon dioxide is important for culture of algae and therefore for maintenance of appropriate watercolour.
3) It facilitates the volatilization of undesirable gases such as N2, NH3, CH4 and H2S.12 4) It reduces the daily fluctuation range of pH value.
5) It accelerates the decomposition and mineralization of organic matter in water and soil and helps in the release of nutritive value of fertilizers.
6) It diminishes the possible stratification of pH, DO, salinity and temperature in the pond water.
7) It helps in mixing the pond water and maintenance of ideal conditions all over the pond.
8) It increases turbidity when necessary.

Details of the importance of physico-chemical parameter and microbiological aspects in aquaculture ponds.

S. No	Parameter	Purpose	Equipment Required	Chemicals and Glassware Required
I	Water quality parameters			
1	Temperature	Maintenance of optimal temperature, fluctuations at high level, leeds to severe effect on entire body of pond and leeds thermal stress on shrimp, algal crash etc. (28 - 32°C)	Mercuric thermometer / Digital thermometer	----
2	Salinity	Eurihaline; tolerance capacity with broad range of salinity (10 - 25 ppt)	Clinometers (Refract meter)	Titrimetric method of knewdson's for standardization of salinometer
3	PH	Little bit basic conditions are favourable (7.4 – 8.5)	Digital PH meter / pH pen	Standardized by Titrimetric method
4	Transparency	Optimal maintenance of plankton density (30 - 40 cm)	Sacchi disc	Primary productivity estimation by dark white bottle method by C^{14} method
5	Dissolved Oxygen	Is the main requirement for physiological & biochemical activities of living things (> 3 mg/l)	D.O. Meter/ Wrinklers method	Chemical and Glassware required burette, pipette, conical flasks, D.O bottles (reagent bottles), beakers etc.
6	BOD	It is necessary to estimate the requisite of oxygen content by the enclosed body of water	D.O method/ Wrinklers method	Chemical and Glassware required burette, pipette, conical flasks, D.O bottles (reagent bottles), beakers
7	COD	The amount of oxygen required for the complete oxidation of all organic/chemical components in the pond environment	Oxidized method	Chemical & Glassware required reflexor, hotplate etc.

8	Nitrate – N	The nutrient content is very high leads to heavy blooming of algae	Spectrophotometer meter/ Calorimeter/kits (YSI, Merck, Loba)	Chemicals & Glassware
9	Nitrite – N	It is an toxic constituent	Spectrophotometer/ Calorimeter/ kits (YSI, Merck, Loba etc.)	Chemicals & Glassware
10	Ammonia–N	It is an toxic constituent	Spectrophotometer/ Calorimeter/ kits	Chemicals & Glassware
11	Phosphate–P	Nutrient	Spectrophotometer/ Calorimeter/ kits	Chemicals & Glassware
12	Hydrogen sulphide	Toxic and makes anoxic conditions	Spectrophotometer/ Calorimeter/ kits	Chemicals & Glassware
13	<u>Sediment analysis</u> a. Sediment organic matter b. Sediment composition	It shows how much of organic matter and organic carbon produced in the pond bottom by the shrimp farming activity. It exhibits the ratio's of sediment components i.e., sand, silt & clay	Titrimetric method Pipette method	Chemicals & Glassware Chemicals & Glassware
II A.	<u>Biological</u> <u>Bacteriological</u>			
1	TVC (Total Viable count of Bacteria)	It reveals the total bacterial forms that harbour the pond environment	Laminar flow chamber, oven, incubator, autoclave, petridishes, test tubes, conical flasks, test tube stand, micropipette, beakers, digital colony counter.	TGY media (Tryptone Glucose Yeast extract Agar)
2	TVLO (Total Vibrio like organizers)	It reveals the total bacterial forms that harbour the pond environment	Laminar flow chamber, oven, incubator, autoclave, petridishes, test tubes, conical flasks, test tube stand, micropipette, beakers, digital colony counter.	TCBS media (Thiamine Citrate, Bile sucrose salt Agar)
3	Other pathogenic bacteria	It reveals the total bacterial forms that harbour the pond environment	-DO-	Different media for respective various bacteria

B.	Virology			
1	Dot Blot method	Viral diseases like WSV, MBV etc.	Kits	-
2	PCR method	Viral diseases like WSSV, MBV etc.	Primers, Thermal cyclar, UV laminar flow chamber, electrophoresis unit, UPS system etc.	-
3	Histopathology	Viral diseases like WSV, MBV etc.	Microtome, staining & distaining equipment and stains.	-
C.	Ectocommensal Parasites	Like Zoothamnium, Vorticella, Fungi etc.	Simple binocular microscope and Compound monocular microscope with CCTV.	-

Water quality parameters for shrimp farming

Water parameter	**Optimum level**
Temperature	26-33 C
Salinity	10-25 ppt
Dissolved oxygen	>3.0 ppm
pH	7.5-8.5
Total Ammonia Nitrogen	<1.0 ppm
Total Nitrate Nitrogen	<5.0 ppm
Nitrite Nitrogen	<0.01 ppm
Sulphide	<0.03 ppm
Biological Oxygen Demand	< 10 ppm
(BOD)	<70 ppm
Chemical Oxgen Demand (COD)	25-45 cm
Sacchi disc visibility	