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Role of Water Quality Parameters in Pond Management: A Review

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Abstract

Fish and all aquatic organisms live in the aquatic medium and perform all their physiological and metabolic activities in the water. The quality of water will determine the quality of an individual. As fish is a vital source of protein from a food point of view along with the fishery sector is a very profitable business in the global market. As commercial aquaculture is increasing day by day countries majority focusing on the aquaculture sector to cope with their economy which will be done only by producing a higher yield. To obtain a better yield or success of the aquaculture system farmers need to provide a suitable environment to fish to enhance fish health profile by maintaining water quality parameters. Water quality characteristics are the key factors that help in the maintenance of fish. These factors include Dissolved oxygen, pH, inorganic and organic materials, water hardness, alkalinity, ammonia, nitrate and temperature. By indicating suitable species according to the environment and maintaining all water quality parameters fish production can be enhanced. All these parameters are interrelated with each other as by increasing the level of temperature the amount of dissolved oxygen and pH will be reduced. By disrupting these parameters there will be a chance to increase the level of ammonia and nitrate which will prove toxic to fish health.

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Introduction

The most growing food production industry related to animals is the aquaculture industry. As the human population is increasing day by day and their demand for food is increasing but the production of food does not meet its required limit. As fisheries are a vital source of protein in the diet but their production stagnates so the aquaculture industry needs to cope up to enhance the yield of aquatic product to meets the desirable range of food for the society (Lehmkoster *et al.*, 2013). All the aquatic organisms including fishes having aquaculture potential stayed in the water medium. It is not wrong to say that the quality of water will determine the success or failure of the aquaculture or fishery operation (Piper *et al.*, 1982). For fish, farming water is the most vital element. In context to fish farming water parameters related to quality and quantity of water should be focused on for better results (Summerfelt, 2000).

By comparing land-based crops i.e. agriculture and animal production, fishes are pretty sensitive related to any toxicity or pollutants in water. So, aquaculture production is susceptible to water-quality corrosion. Along with that, the excessive use of chemicals had a huge and detrimental impact on the ecosystem as well as on the environment. Some scientists hypothesized that chronic exposure to high unionized ammonia concentrations and other toxic components would badly abrupt the fish's well-being (Becke *et al.*, 2019). Ignoring water quality parameters and unreasonable fish farm management is a major cause for the emergence of disease in fish culture and leads to major loss to the aquaculture industry (Veiga *et al.*, 2016).

The totality of physical, biological and chemical parameters is the water quality that affects the progress, growth, survival, reproduction and well-being of cultured organisms. Commercial aquaculture production would majority dependent on a condition to provide them an optimum or suitable environment for their rapid growth. Water quality greatly affects the overall condition of the cultured organism as it regulates the health profile and growth conditions of the cultured organism (Mallya, 2007).

All physiological activities relate to fish which includes breathing, excretion of waste, feeding, maintaining salt balance and reproduction were required a liquid medium and held in water. So, the most determining factor on which the operation of aquaculture will depend is on the quality of water (Boyd, 1998). The perilous parameters are temperature, suspended solids and concentrations of dissolved oxygen, ammonia, nitrite, carbon dioxide and alkalinity. Though, dissolved oxygen is the furthermost imperative and serious parameter, demanding unceasing nursing in aquaculture production systems. This is due to fact that fish's aerobic metabolism entails dissolved oxygen (Timmons *et al.*, 2001). The pond's net production can be measured as the net volume of oxygen formed by the pond (Hall and Moll, 1975). This paper basically provide the information regarding water quality parameters and their importance in water bodies. How these physiochemical parameters are interlink with each other and their impact on aquatic bodies. By maintaining these physiochemical parameters the health and yield of aquatic biodies can easily obtained. Aquatic bodies lives in a water medium so there is urge to maintain aquatic environment in a desirable range for the health profile of aquatic bodies.

Dissolved oxygen

The content of oxygen gas molecules which is dissolved in water was referred to as dissolved oxygen (DO). Like other animals fish also need oxygen for breathing purposes. Fish can take up the content of oxygen from water into their bloodstream by using gills while other land animals directly take oxygen from the air through the lungs.

Oxygen in the water bodies comes from the atmosphere when water comes in contact with the air it transfers its oxygen molecules to water including river and lake water and this is the oxygen which all the aquatic organisms including fish were used to breathe (Francis-Floyd, 1997).

The volume of oxygen that can be dissolved in water depends on many abiotic factors which include water temperature, the number of dissolved salts presents in the water (salinity), and atmospheric pressure (Wilson, 2010). The oxygen desires of fish also rely on several other aspects, including the temperature, pH, and CO_2 level of the water, and the metabolic rate of the fish. The foremost principles for the oxygen necessity of fish include temperature, and the average individual weight and the total weight of fish per unit volume of water (Svobodová, 1993).

The most significant abiotic factor which determines the growth and survival of fish is the dissolved oxygen content in the water (Taylor and Miller, 2001) and aquaculture (Piper *et al.*, 1982). By increasing the level of DO there will be an increase in the feed consumption, feed efficiency, metabolism, and fish growth (Neill and Bryan, 1991; Jobling, 1993; Van Dam and Pauly, 1995; Buentello *et al.*, 2000). The level of DO in water is intensely affected by stocking density, water temperature, and water flow. By generating a high level of DO through increasing water flow it will minimize ammonia and other toxic components in the water and decreasing the level of DO by raising water temperature also affects fish metabolism (McDaniel *et al.*, 2005).

According to Fick's law of diffusion, the proportion of diffusion of oxygen across the gills is determined by the gill area, the diffusion distance across the gill epithelia, the diffusion constant and the alteration in the partial pressure of oxygen across the gills (Crampton *et al.*, 2003). Therefore, the partial pressure of oxygen is the furthermost suitable term for stating oxygen levels in aquaculture water. Additionally, the appropriate method for stating oxygen levels in aquaculture is % air saturation which is directly proportional to the partial pressure and is described on most oxygen probes that have built-in algorithms for temperature and salinity (Bergheim *et al.*, 2006).

In the fish pond culture system, the major source of oxygen production is from the algal photosynthesis as well as from the atmosphere. Along with the natural production of oxygen in the pond, there is an alternative or artificial source for oxygen too. Especially in tanks or raceways, the oxygen is supplied by using aerators or by the maximum inflowing of water which should be close to saturation for the temperature and elevation (Summerfelt, 2000). Mainly oxygen is produced by three sources which include, direct diffusion from the atmosphere, wind and wave action and photosynthesis.

The most significant way for oxygen production is through the process of photosynthesis. During the day there is maximum production of oxygen due to the solar energy radiations which organisms utilize for their all activities but at night the level of oxygen drops due to the respiration of plants and animals (Francis-Floyd, 1997).

The natural mechanism for the production of oxygen in the pond is photosynthesis. While compared to photosynthesis, total oxygen gains and loss due to diffusion during daylight is minor. The proportion of DO in the hypolimnion layer is commonly less than 2 mg/l but amplified at night during the period of vertical circulation. Hypolimnion oxygen deficit (HOD) was discovered with the in situ DO level. HOD was set up to upsurge during the daylight period and decrease at night after destratification (Chang and Ouyang, 1988). The level of DO will be reduced up to great extent due to excess vegetation or the cover of floating plants (Gee *et al.,* 1997). For better pond management the level of phytoplankton production should be maintained at an appropriate level to enhance the oxygen content to avoid macrophyte growth, for the supply of nutrients to fish either directly or indirectly (Smith and Piedrahita, 1988). An excess amount of phytoplankton production disrupts the water quality parameter by producing detrimental algal blooms which disturb the fish health profile (Boyd, 1982; Costa-Pierce, 1985; Sin and Chiu, 1982; Smith, 1985). Shading, turbidity, depth, temperature, and nutrient richness tend to be negatively interrelated with dissolved oxygen concentrations in stagnant water bodies (Kramer, 1987).

The response of fish towards hypoxia

Hypoxia is a basic phenomenon shown by all the aquatic organisms especially fishes in response to the low availability of oxygen in their living system. Lacking DO level (0% saturation) in aquatic system labelled as anaerobic. Dropping or anoxic is a system with a low DO ratio in the range between 1 and 30%. DO saturation is called hypoxic. Most fish cannot survive below 30% DO saturation. For a good or healthy aquatic environment level of DO should rarely experience the range of DO less than 80%. Low dissolved oxygen level arises in ponds mainly when algal blooms die-off and succeeding decomposition of algal blooms and can be a source of stress or mortality of cultured organisms in ponds. Frequently low dissolved oxygen levels can reduce growth, feeding and molting frequency (Boyd, 1990).

As a result of low DO level the response of fish might be in two ways which include the blood flow can be amplified by opening up additional secondary lamellae to rise the effective respiratory area, and the concentration of red blood corpuscles can be improved to raise the oxygen-carrying capacity of the blood per unit volume. The latter can be attained by dropping the blood plasma volume in the short term and by discharging extra blood corpuscles from the spleen in the longer term (Svobodova *et al.,* 1993). Depending upon the requirement of oxygen and their rate of adaptation to the environment for each species, hypoxia will cause stress to fish which alternatively disrupt fish health profile by disturbing its immunity level and ultimately cause mortality. In anoxia condition, fish will respond differently by reducing their feed consumption, move to the surface of water and gasp for air, gather at the water inflow point of the pond due to the high oxygen ratio at that point, become inactive, fail to react to anger, lose their capability to escape arrest and eventually die (Svobodova *et al.,* 1993).

The level of DO should be maintained at almost 24 hours but culture species respond immediately in the context to low DO levels especially at night (Boyd and Hanson, 2010). Hypoxia may delay fish growth, feed utilization, and affect fish health status so that fish could adopt numerous mechanisms to cope with a lessening of DO uptake. The diverse coping styles in individual fish may influence fish health and susceptibility to bacterial infection (MacKenzie *et al.*, 2009; Huntingford *et al.* 2010). The factors triggering oxygen shortfalls include biological and chemical oxidation, microbial degradation and organism respiration (Chang, 1985). The main classifications of behavioral response to lessen external availability of dissolved oxygen changes in activity, increased use of air-breathing, increased use of aquatic surface respiration and vertical or horizontal habitat changes (Kramer, 1987).

Hypoxia conditions also affect fish reproduction strategy including both fertilization success and the survival of larvae. Energy consumption is decreased, related to a shift from aerobic to anaerobic metabolism. To diminish energy spending under this condition, fish interchange to water at lower temperature and decrease activity, reproduction, feeding and protein synthesis. Commonly, the activities of toxicants are aggravated during hypoxia through various mechanisms. Some species are greatly more tolerant of hypoxia than others leading to different survival during prolonged periods of hypoxia (Poon *et al.,* 2002).

Impact of oxygen on fish growth

For any animal, oxygen is the most significant component for respiration and metabolism processes. Specifically, in fish, the rate of metabolism is widely affected by the amount or ratio of oxygen content in the rearing environment. As the level of DO falls the rate of respiration and the activities related to feeding will slow down which eventually decreases or cease the growth of cultured species and also reducing the feed conversion ratio of the organism. By decreasing the level of DO it will badly impact the growth of fish and there will be a great chance to reduce the immunity and allow the parasites to attack and cause disease (Tom, 1998). Special attention should be delivered to maintain the level of DO at the saturation level according to the species optimum range which will not alter or effects fish physiological or metabolic activities which in return results in a high yield or production in any rearing aquatic system (Wedemeyer, 1996). Along with that farmers must keep in mind that every species has its requirement for DO which should be maintained and the level of DO also dependent on the size of fish and the activities of fish (Table 1) (Mallya, 2007).

Table 1. The optimum range of dissolved oxygen in the context of different fish species.

Serial No.	Species	Optimum range for DO	References
1	Channel Cat Fish	< 3mg/L	(Boyd and Hanson, 2010)
2	Tilapia	<1mg/L	(Boyd and Hanson, 2010)
3	Penaeid Shrimp	< 3mg/L	(Boyd and Hanson, 2010)
4	Atlantic Sturgeon	78.4–127.5% saturation	(Niklitschek and Secor, 2009).
5	Brown Shrimp	< 2.5mg/L	(Neilan and Rose, 2014)
6	Grass Shrimp	< 1.5mg/L	(Neilan and Rose, 2014)
7	Summer flounder	7mg/L	(Stierhoff *et al.,* 2006)
8	Winter flounder	7mg/L	(Stierhoff *et al.*, 2006)
9	Killifish	7mg/L	(Landry *et al.*, 2007*),* (Cheek, 2011)
10	Atlantic Halibut	90-120% saturation	(Mallya, 2007)
11	*Oreochromis niloticus*	6-6.5mg/L	(Abdel-Tawwab, 2015)
12	*Oncorhynchus mykiss*	10mg/L	(McDaniel *et al.*, 2005)
13	Channel Cat Fish	>2mg/L	(Summerfelt, 2000)
14	Rainbow trout	3mg/L	(Summerfelt, 2000)
15	Salmonids	8-10 mg/L	(Svobodová, 1993)
16	Cyprinids	6-8 mg/L	(Svobodová, 1993)
17	Northern Pike	6 mg/L	(Wetzel, 1983)
18	Salmonids	6 mg/L	(Rehman, 2019).
19	Trout Eggs	11 mg/L	(Rehman, 2019).
20	Juvenile catfish	<1 mg/L	(Wilson, 2010)
21	Rainbow trout (Yearlings)	<2.5 mg/L	(Wilson, 2010)
22	Red Swamp crawfish	<2 mg/L	(Wilson, 2010)
23	Northern Pike	6 mg/L	(Wolf ,1963)
24	Black Bass	5.5 mg/L	(Wolf, 1963)
25	Common Sunfish	4.2 mg/L	(Wolf ,1963)
26	Yellow Perch	4.2 mg/L	(Wolf ,1963)
27	Black Bullhead	3.3 mg/L	(Wolf, 1963)
28	Tilapia	>5 mg/L	(Lioyd, 1992)
29	Trout	10 mg/L	(Lioyd ,1992)
30	Marine Fish	>6 mg/L	(Huguenin and Colt, 1989)
31	Cold Water Fish	>6 mg/L	(Lawson, 1995)
32	Salmon	>8.5 mg/L	(Black, 1992)
33	Eel	>5 mg/L	(Lioyd,1992)
34	Carp	>5 mg/L	(Lioyd,1992)
35	*Penaeus vannamei*	6-10 mg/L	(Clifford, 1994)

Temperature

The gradation of hotness or coldness in the body of any living organism either it wills on land or in water termed as temperature (Lucinda and Martin, 1999). Temperature is a significant water factor due to its impact on quality and quantity for the simplification of other water parameters along with that it also regulates many physical characteristics of a water body. In a cool environment or low atmosphere temperature, water's temperature-dependent density permits aquatic life to stay alive (Smith *et al.*, 1996). Physiological progressions in fish such as respiration rates, feeding, metabolism, growth, behavior, reproduction and rates of detoxification and bioaccumulation are pretentious by temperature. Temperature can also alter methods vital to the dissolved oxygen level in water such as the solubility of oxygen, and the rate of oxidation of organic matter. All these perceptive temperatures also play their role in affecting the solubility of fertilizers (Assessment, 1999). Temperature also plays a significant role in the rate of photosynthesis of aquatic plants, the base of the aquatic food web. At higher temperatures, the toxicity level of the pollutant can be enhanced due to a lesson in DO. The volume of dissolved oxygen becomes lesser as the water temperature rises. Water temperature is one of the most imperative water quality factors that affect the growth, food intake, reproduction and several other biological activities of aquatic organisms. Normally, the metabolic demand for oxygen uptake in aquatic organism become double or triples with every 10°C increase within the range of temperature that an individual can tolerate (Begum *et al*., 2004).

Table 2. The optimum range of temperature in the context of different fish species.

Serial No.	Species	Optimum range for Temperature	References
1	*Oreochromis mossambicus*	24°C	(Gabriel *et al.*,2020)
2	*Oreochromis mossambicus*	28°C	(Gabriel *et al.*, 2020)
3	Largemouth Bass	32.2°C	(Summerfelt, 2000)
4	Tilapia	<10°C	(Summerfelt, 2000)
5	Salmon	>25.7°C	(Summerfelt, 2000)
6	Channel Cat fish	29.5°C	(Summerfelt, 2000)
7	Rainbow trout	15°C	(Summerfelt, 2000)
8	Arctic Char	10-12°C	(Summerfelt, 2000)
9	Major Carps	28-32°C	(Bhatnagar *et al.*, 2004)
10	*Penaeous monodon*	25-30°C	(Bhatnagar *et al.*, 2004)
11	Tropical species	29-30°C	(Boyd, 1990), (Lawson, 1995)
12	Warm Water species	20-28°C	(Boyd 1990) and (Lawson 1995)
13	Cool Water species	15-20°C	(Boyd, 1990), (Lawson, 1995)
14	Cold Water species	<15°C	(Boyd, 1990), (Lawson, 1995)
15	Brook Trout	7-13°C	(Piper, 1982)
16	Brown Trout	12-14°C	(Petit, 1990)
17	Brown Trout	9-16°C	(Piper, 1982)
18	Rainbow trout	14-15°C	(Petit,1990)
19	Rainbow trout	10-16°C	(Piper,1982)
20	Atlantic Salmon	15°C	(Petit, 1990)
21	Chinook Salmon	10-14°C	(Piper, 1982)
22	Coho Salmon	9-14°C	(Piper, 1982)
23	Sockeye Salmon	15°C	(McNeely *et al.*, 1979)
24	Sole	15°C	(Petit, 1990)
25	Turbot	19°C	(Petit, 1990)
26	Plaice	15°C	(Petit, 1990)
27	European eel	22-26°C	(Petit, 1990)
28	Japanese eel	24-28°C	(Petit, 1990)
29	Common Carp	25-30°C	(Petit, 1990)
30	Mullet	28°C	(Petit, 1990)
31	Tilapia	28-30°C	(Petit, 1990)
32	Channel Catfish	27-29°C	(Tucker and Robinson, 1990)
33	Channel Catfish	21-29°C	(Piper, 1982)
34	Striped Bass	13-23°C	(Piper, 1982)
35	Red Swamp Crawfish	18-22°C	(Romaire, 1985)
36	*Penaeus vannamei*	28-30°C	(Clifford, 1994)
37	Freshwater Prawn	30°C	(Romaire,1985)
38	Brine shrimp	20-30°C	(Romaire, 1985)
39	Brown Shrimp	22-30°C	(Romaire, 1985)
40	Pink Shrimp	>18°C	(Romaire, 1985)
41	*Oreochromis niloticus*	31°C	(Begum *et al.*, 2004)
42	Largemouth Bass	23.5°C	(McNeely *et al.*, 1979)
43	Coho Salmon	20°C	(McNeely *et al.*, 1979)

It is one of the supreme central external factors which affect fish production. At temperatures above or below optimum, fish growth is decreased and mortalities may occur at the extreme rise in temperatures (Joseph *et al.*, 1993). The temperature has many other effects because phytoplankton and zooplankton also respond to water temperature. Due to rising in temperature, there is a great chance of an increase in the rates of chemical reactions, and fertilizers and liming material applied to ponds will dissolve faster. Due to rising in temperature, there will be a rise in respiration activities of all aerobic organisms including culture species, phytoplankton, zooplankton and other bacteria. This is the reason that depletion in DO will cause a major threat to the well-being of aquatic animals at the rise in temperature (Boyd, 2018).

It is tough and almost impractical to raise or down the temperature of large volumes of an open pond or in raceways. Species must be selected according to their predicted water temperature range. Farmers must know about the desirable or optimum temperature ranges which were required for aquatic organisms for different activities including egg incubation, growth and development of larval fish, and for production of a food-size fish (Table 2). The ectothermal animals which include bacteria, insects, zooplankton, frogs and turtles as well as fish temperature are a serious environmental aspect that toughly influences feeding and growth. Sudden alteration in the temperature ranges either rises or falls it will induce stress level in fishes which ultimately becomes the reason for disease outbreak. Sudden alteration to temperature or temperature shock comes when fish moves from one environment to another atmosphere without any acclimation to other temperature causes stress in fishes. Temperature plays their vital role in controlling the solubility of gasses in water, the reaction rate of chemicals, the toxicity of ammonia, and chemotherapeutics to fish (Summerfelt, 2000).

Fish are poikilothermic animals so, their body temperature remains the same but alters 0.5 to 1°C above or below, the temperature of the water in which they survive. The metabolic rate of fish is narrowly correlated to the water temperature means a rise in the water temperature causes an increase in the metabolism particularly to warm-water fish. Cold-water fish have a different way of metabolism, their metabolic rate can endure at relatively low temperatures, whereas at higher water temperatures they become less active and consume less food. Water temperature also has an excessive impact on the initiation and course of some fish diseases. The immune system method of almost all fish species has an optimum routine at water temperatures of about 15°C (Svobodová, 1993).

As fish is a cold-blooded animal, its body temperature changes according to that of environment upsetting its metabolism and physiology and eventually affecting the production. Higher temperature raises the rate of bio-chemical activity of the microbiota, plant respiratory rate, and along with this, there will increase in oxygen demand. It supplementary roots in the reduction in solubility of oxygen and also increased level of ammonia in water. Though, under prolonged ice cover the gases like hydrogen sulphide, carbon dioxide and methane, etc. can build up to hazardously high levels affecting fish health status (Bhatnagar and Devi, 2013).

Alkalinity

The presence of base quantity is known as total alkalinity. Some common bases are found in fish ponds, for example, hydroxides, carbonates, bicarbonates, phosphates and berates. The most important components of alkalinity are carbonates and bicarbonates. It is measured by the amount of acid or the presence of hydrogen ions. A tolerable range of total alkalinity for fish culture is between 75 and 200 mg/L $CaCO_3$ (Saleh *et al.,* 2010). The most common water quality variables are total alkalinity and hardness. These are important to water supply and its use as well in the productivity of the aquatic environment, and aquaculture construction. Alkalinity and hardness of water are important functions of the geology of this area. The percolation of rain and surface water along with the dissolved carbon dioxide of the atmosphere is another function. Rainwater in nature is acidic. It dissolves some minerals more easily (Arabi *et al.*, 2011).

pH

(Boyd and Claude, 1979) reported that pH varies due to change in other water quality parameters. pH can be defined as the negative logarithm of the molar hydrogen ion concentration (-log [H+]). Water is a weak electrolyte and becomes neutral at pH 7. It becomes acidic when pH is below 7 and basic when pH is above 7. The optimum pH range for aquaculture is 6.5 to 9.0. The average blood pH for fish and other vertebrates is 7.4. A desirable range of pH for pond water would be close to fish blood for example 7.0 to 8.0. If the pH drops below 5 or rises above 10, fish may become stressed, lethal and die. In aquatic systems, compounds that affect pH are produced incessantly. The most important of these are carbon dioxide and ammonia. The addition of carbon dioxide releases free hydrogen ions which drops pH and the water becomes more acidic (Boyd *et al*., 2016).

Alkalinity and pH

(Wurts and Durborow, 1992) reported that carbonate and bicarbonate ions produce alkalinity and hardness in the aquatic system. This water is produced mainly through the relations of CO_2, water and limestone. Rainwater becomes acidic due to exposure to atmospheric carbon dioxide. When rain falls to the earth, each droplet becomes saturated with CO_2 and lowered the pH. Healthy water is pumped from large, natural underground reservoirs, local pockets of underground water. Naturally, underground water has high concentrations of CO_2, and oxygen concentrations and low pH. (Kahara and Vermaat, 2003) determined carbonates and bicarbonates chemically react with both acids and bases and neutralized the pH range. The pH of pure buffered water normally varies between 6.5 and 9. In waters that have low alkalinity, pH dramatically reaches a low level when plants do respiration or dangerously high when photosynthesis occurs. Alkalinity improves phytoplankton productivity by stabilizing pH at or above 6.5. Alkalinity can be improving by increasing nutrient availability such as nitrogen and phosphate concentration. Alkalinities at or above 20 mg/L absorb CO_2 and increase the pH.

Jezierska and Witeska (2006) determined that the discharge of carbonate transformed from bicarbonate by plant life. Due to this transformation, pH climbs dramatically (above 9), when plants perform photosynthesis by dense phytoplankton. This indicated that pH is high in low alkalinity water (20 to 50 mg/L). The optimum range of bicarbonate alkalinity is (75 to 200 mg/L) in water that has less than 25 mg/L hardness. High bicarbonate alkalinity in soft water is formed by sodium and potassium carbonates. These are more soluble in water as compare to calcium and magnesium carbonates that cause hardness. Limestone is formed, when calcium, magnesium and photosynthetically produced carbonate are present when pH is greater than 8.3. Ponds with alkalinities below 20 mg/L do not usually carry good phytoplankton blooms and do not commonly experience remarkable pH increases because of high photosynthesis.

Hardness and high pH in ponds

Low hardness and high alkalinity properties are mostly founded in high pH ponds. This characteristic of high pH ponds is related to the production of CO_2. CO_2 is released rapidly from water by plants during photosynthesis with the combination of the high solubility of monovalent cation salts of $CO_3{}^{2-}$. Now there is one way to become less extreme the effect of photosynthesis on pH is to increase calcium concentrations by providing calcium sulfate. The application of enough calcium sulfates to exceed the hardness to the same concentration as the alkalinity is known to be the usual treatment ratio. This ratio of pure gypsum to hardness is 1.72:1, but agricultural gypsum is not 100% $CaSO_4{\cdot}2H_2O$, and a ratio of 2:1 generally is utilized (Boyd *et al*., 2011).

Carbon dioxide, alkalinity, hardness and pH

(Teichert-Coddington *et al*., 1992) explained the carbon extraction in photosynthesis. In the reduction of CO_2 during photosynthesis, CO_2 could directly reduce total inorganic carbon in water or could also change pH and cause $CaCO_3$ to be precipitated by reducing alkalinity. After hydrolysis of urea and phosphate, the inorganic nutrients can be increased that might have assisted an increase in the photosynthetic activity. So this might be caused the reduction in total alkalinity in the present study thoroughly. Similarly, the dose depends upon high alkalinity concentrations in treatments of organic input occurred possibly due to the adequate supply of inorganic carbon to water after the microbial transformation of organic carbon sources addition. Diana, Szyper, Batterson, Boyd and Piedrahita (1997) also observed the reduction of pH and increase alkalinity by increasing the CO_2 concentration after application of organic manure.

Cogun and Kargin (2004) reported that changes in alkalinity, low pH and hardness cause acidity in water. The acidic environment indirectly enhances the accumulation of heavy metals in fish. These heavy metals affect the fish physiology specially gills epithelial cells. Poleksic and his companion reported that the accumulation of Zn, Pb, Cu, Mg, Fe, Mn and as in the fish liver, gills and skin is due to the water pollutant. But, due to the acidic environment, pH decrease and Hardness increase. The hardness of water prevents these metals from absorption by fish.

Ammonia and nitrate

Ammonia is a dissolved gas present naturally in all types of water such as surface water, wastewater, and in some well waters. Sourced through which it is added in water is from the nitrogenous waste product of fish as it is fed with protein feed as well as from the decomposition of organic matter in the form of uneaten food, dead algae and aquatic plants (Stone and Thomforde, 2004).

It is quite soluble in water, especially at low pH, and can be utilized by plants or bacteria as a source of energy. The utilization of ammonia by plankton algae also minimizes the amount of ammonia available to fish in the water. Ammonia is present in different forms in water which collectively is known as Total ammonia nitrogen (TAN). It is present as toxic un-ionized ammonia (NH_3) and non-toxic ionized form (NH_4^+). This non-toxic form (ammonium ion) is present when it is dissolved in water (Stone and Thomforde, 2004). The prevalence of these two forms in water is affected by pH and temperature. pH and temperature have an inverse effect as a decrease in these parameters increases the dissolution and ionization of ammonia and non-toxic form increases in the water that cause no harm to fish (Norm, 1996). The toxicity of ammonia to fish also varies from species to species as some can acclimate to high ammonia levels while others cannot. For example, Catfish adapt to high ammonia levels, and in commercial ponds, 2 to 5 mg/l of total ammonia nitrogen is common in the spring and fall. Uncontrolled ammonia levels during catfish cultivation cause slowing of growth, inability to breed and failure to harvest (Pulungan *et al.*, 2020).

In the case of high pH, the toxic form i.e un-ionized ammonia predominates while at low pH relatively non-toxic form that is ammonium ion is present in abundance. When pH is less than 8.0, less than 10% of ammonia is in the toxic form but with further increase in pH, this proportion increases dramatically. Usually, a small portion of the TAN exists as toxic (un-ionized) ammonia, and there is an equilibrium between it and the nontoxic ionized ammonia. But this balance is also affected by temperature. Warmer water contains more toxic ammonia as compared to colder water (Hargreaves and Tucker, 2004). Lower water temperatures slow down aerobic bacterial activity, thus slowing the nitrification process whereby ammonia is converted to harmless nitrate (Robert *et al.*, 1997).

According to water quality standards, the desirable range for total ammonia is 0-2 mg/l, for unionized ammonia is 0 mg/l and for nitrite is 0-1 mg/l. While the acceptable range under which fish can survive, for total ammonia less than 4 mg/l, for unionized ammonia is less than 0.4 mg/l and for nitrite is less than 4 mg/l (Stone and Thomforde, 2004).

High ammonia concentration in its toxic form has a negative effect on fish such as damage to gills and mucous producing membranes, increase in blood pH, influence on fish permeability and reduction of the internal concentration of ions, increase in consumption of oxygen by the tissues. It also reduces blood capability to transport oxygen, increases susceptibility to diseases and causes histological changes mainly in the kidney and dull (Hargreaves and Kucuk, 2001; Ismino-Orbe *et al.*, 2003; Cavero *et al.*, 2004).

Regular water change, the addition of quicklime in their fish ponds by farmers can compensate for a high level of ammonia (Bhatnagar and Devi, 2013). Other ammonia management practices are lowering feed rate, the addition of phosphorus, increase in pond depth, flush the pond with well water, the addition of bacterial amendments, source of organic carbon, acid and ion exchange materials (Hargreaves and Tucker, 2004).

Another nitrogenous compound present in water is a nitrate which is formed as a result of the bacterial breakdown of ammonia. Ammonia is first converted into nitrite and then to nitrate which is the final stage of the natural biological metabolic waste conversion. Although it is less toxic, nitrate as a nitrogen compound causes stress (even in small concentration) to fish making its organs work harder to adjust to their new environment. This stress also affects the immunity of fish, increases susceptibility to diseases, decreases the ability to heal and the ability to reproduce (Kiran, 2010).

Naturally, for fish, there is an almost nitrate-free environment with levels around 5 ppm or less. Fish will be extremely under severe stress if the level of nitrate in water exceeds 60 ppm. Most of the plants fail before reaching this level. This is due to an accumulation of life forms that feed on the waste and then higher biomass (animals living in the aquarium) leads to increasing demand for oxygen (Norm, 1996).

That is the reason most of the pesky and unwanted algae grow in water having poor quality, high level of nutrients and nitrate. Therefore, nitrate levels (NO_3) should be kept below 10ppm (Damon, 1999).

Fish that are exposed to high concentrations of nitrate may face a reduction in the hemoglobin concentration as this molecule is converted into metahemoglobin by toxic nitrites. As the structure of hemoglobin is altered, its capability to transport oxygen to the tissues is also reduced. This condition leads to hypoxia even when oxygen is highly dissolved into the water but cannot be taken up by hemoglobin (Sampaio *et al.*, 2006).

Different methods can be used to effectively remove nitrate from wastewater such as ion exchange, reverse osmosis, electrochemical processes, and biological treatment (Shrimali and Singh, 2001; Koparal and Ogutveren, 2002; Mohan *et al.*, 2016). Constructed wetlands and sequencing batch reactors (SBRs) are commonly used to remove nitrate from wastewater (Wu *et al.*, 2009; Mohan *et al.*, 2016) through denitrification to convert nitrate back to nitrogen. Denitrification, an important nitrogen removal mechanism that can ameliorate the effects of nitrogen pollution via conversion of nitrate to nitrogenous gas (Kraft *et al.*, 2014; Ward and Jensen, 2014; Morrissey and Franklin, 2015), is the major pathway for the removal of nitrogen from water bodies (Laverman *et al.*, 2010).

Conclusion

All the water quality parameters are interrelated to each other and heavily influence the fish health status. There is a need to minimize the excessive production of phytoplankton by which level of DO drop and rise in pH which will ultimately cause ammonia and nitrate and other toxicants which is hazardous for fish health. Due to an increase in the alkalinity and hardness, pH decreases and the environment become acidic. And the environment becomes acidic due to increasing carbon dioxide concentration and forms carbonic acid. The point of concern is to manage all the required water quality parameters according to the species desirable range.

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