Journal of Agriculture and Veterinary Sciences
Volume 9, Number 2, 2017
ISSN: 2277-0062

PHYSICOCHEMICAL PARAMETERS OF WATER AND THEIR EFFECTS ON FISH PRODUCTION

Kasim Lawal Ibrahim

Department of Agricultural Science Education
Federal College of Education (Technical) Bichi, Kano State
Email: talk2klawal@yahoo.com

ABSTRACT

Water quality includes all physical, chemical and biological factors that influence the beneficial use of water where fish culture is concerned any characteristic of water that affects the survival, reproduction, growth, production or management of fish in any way is a water quality variable (Boyd, 1990). There are many water quality variables in pond fish culture, fortunately only a few of these normally play an important role. These variables are what fish farmers should concentrated on an attempt to control to some extend by management techniques. These physicochemical parameters includes; Temperature, pH, Dissolve oxygen, Turbidity, color, Hardness and salinity. etc. Since water is the entire home/environment of Fishes it's good to the fish farmers to understand some basic water quality management techniques in order to achieve successful fish farming.

INTRODUCTION

Rearing of fish in pond is rapidly developing in Nigeria, however many interested fish farmers who lack basic knowledge of rearing fish in pond are facing problem in the area of managing good water quality in their ponds (Ajayi, 2004). Obviously, there are many water quality variables in pond fish culture. Fortunately, only a few of these normally play an important role. These are variables that fish farmer should concentrate on, and attempt to control to some extent by management techniques (Boyd, 21979).

Water quality includes all physical, chemical and biological factors that influence the beneficial use of water. Where fish culture is concerned, any characteristics of water that affects the survival, reproduction, growth, production, or management of fish in any way is a water quality variable (Boyd, 1990). Since water is the entire home environment of fishes, these write up intends the fish farmers to understand some basic water quality management techniques in order to achieve successful fish farming.

These physicochemical parameters includes; temperature, dissolved oxygen, pH (Hydrogen ion) turbidity, color, transparency, light intensity, hardiness, alkalinity, salinity, conductivity, ammonia, hydrogen sulfide, magnesium, phosphate – phosphorus, sodium, calcium, zinc, carbon dioxide, etc.

Ajayi, (2004) observed that transparency and turbidity of water in fish pond can tell the fish farmer a lot about what the water is best for. These two parameters, i.e. turbidity and transparency are good indicators of the quality of pond water without going into the dissolved oxygen, nutrient content of the water and pH (hydrogen ion concentration) which require expensive equipment. A good water conditions is a necessity for the survival and growth of the fish, since the entire life process of the fish wholly dependent of the quality of its environment. The paper discussed the important of fish in the culture environment. These physical, chemical and biological qualities of water should be closely monitored by a fish farmer when raising fish in artificial pond.

Temperature

The sun is the primary energy source on earth; the sunlight brings solar energy to ponds, which is absorbed, warming up the water mass. The low thermal conductivity of water restricts the heat to the upper water layers. Evaporation of water and diffusion of gases in solution in the water cause heat losses.

Temperature is known to effects the behavior, feeding growth and production of fish in general. It has pronounced effects on chemical and biological process. The rate of chemical and biological reaction of every 10^0C increase in temperature, Fishes are known to have poor tolerance to sudden changes in temperature (Body & Lichtkoppler, 1979). Therefore, fish farmers, should not suddenly thrust them into a water of appreciably higher or lower temperature.

According Badiru, (2005) He stated that fish readily tolerate gradual changes in temperature. For example, fish farmer could raise the temperature from 25^0c to 32^0c over several hours without harming the fish. Laboratory mercury in glass thermometer can be used to detect the temperature of the fishpond water, so that action can be taken to reduce or increase the water temperature as the case may be. The optimal temperature range of 25 - 32^0c should be maintained at all time (Badiru, 2005).

Temperature is a factor of great importance for aquatic ecosystems, as it affects the organisms as well as the chemical and physical characteristic of water. For example, the metabolism of cold – blooded organisms is dependent on temperature, as are the solubility of dissolved oxygen, and the density and viscosity of water. Therefore, there is a need to keep pond water within some range, avoiding temperature which is either to high or too low, and agreement with the temperature requirements of cultured organisms. (Boyd, 1979)

Dissolved Oxygen (DO)

Dissolved oxygen is one of the key factors of life. Oxygen is much more important to aquatic than terrestrial life (Badiru, 2005). As oxygen has low solubility in water and is often a limiting factor for life in water (Boyd, 1979). Some species are able to breathe the atmospheric oxygen, by surfacing and gulping air, and do not rely entirely on oxygen dissolved in water. However, oxygen is also needed for all oxidation, nitrification, and decomposition processes.

Badiru, (2005) also stated that maintenance of sufficient dissolved oxygen in fish pond at all time is without doubt, the most essential of water quality management tasks performed by the fish farmer. Its presence in good quality in fish pond will improve the water quality in fish pond by oxidizing poisonous gases such as' ammonia, carbon dioxide, etc into their non-poisonous forms like ammonium salt, carbonate, and bicarbonate.

Low dissolved oxygen level can be lethal, resulting in acute fish anoxia and reduces fecundity, thereby, preventing spawning and egg hatchability. It also retards growth of embryo, juveniles and lead to eventual mortality (Okaeme, 1990).
According to Boyd (1981) warm water fish survive at dissolved oxygen level as low as 1mg/litre, but the growth is slowed down by prolonged exposure. A developed oxygen scale for warm water fish by Swingle is shown in the table below:

Dissolved Oxygen	**Effect**
Less than 0.3mg/liter	Fish die after short term exposure
0.3mg/liter to 1mg/liter	Lethal for long-term exposure
1mg/liter to 5mg/liter	Fish survive but growth is low for long term exposure
More than 5mg/liter	Minimum for warm water fish, and is the desirable range (Fast growth).

As inadequate dissolved oxygen concentration in fish pond affect fish growth and reproduction, minimal constant value of 5mg/liter should be maintained at all times (Badiru, 2005).

Factors Influencing the Level of Dissolved Oxygen in Water

There are three (3) major factors that influence level of dissolved oxygen in fish pond (Boyd et al, 1978). These are:

i. **Temperature**: Oxygen solubility in fish pond water decrease with increasing temperature and increasing salinity.

ii. **Photosynthesis**: The magnitude of daily changes in oxygen concentration in fish pond water influenced by phytoplankton density. Oxygen is lowest at sunrise, before photosynthesis becomes active, increase during the daylight hours to peak in late afternoon or early evening, and declines at night.

iii. **Respiration by Zooplankton:** Fish and benthic organisms and decomposition of organic matter.

Hydrogen – Ion (pH)

PH is a measure of the hydrogen-ion concentration and indicates whether the water is acidic or basic in reaction. The pH-scale ranges from 0 to 14, with pH 7 the neutral point. Thus, a water of pH 7 is neither acidic nor basic, while water with pH below 7 is acidic and one with a pH above 7 is basic. The greater the departure from pH 7, the more acidic or basic of the water (Boyd, 1979)

PH is important as a measure of the acidity of the fish pond water. PH affects many chemical and biological processes in the water. It is known to influence the toxicity of certain chemicals like ammonia, sulfides and cyanide in water. (Dupree and Huner, 1984)

Many aquaculture research scientists agreed that fresh waters with alkaline pH have potential to be productive and suitable for fish culture (Adeniji, 1986; Boyd, 1979). Acid waters (pH below 6.5) will not have good plankton growth and so will not be productive. Generally, fresh water fish cannot survive in waters below pH 4 and above pH 11 for long period. The optimum pH for fish is between 6.5 and 9 (Boyd, 1979).

The effects of pH on warn water pond fish are shown below:

PH	**Effects on Fish**
4	Acid death point
4 – 5	No reproduction
5 – 6.5	slow growth
6.5 – 9	Desirable range for fish production
9 – 10	Alkaline. Death point

Large changes in pH tend to stress fish and reduce growth. This can be avoided by liming to increase the bicarbonate/carbonate concentrations and buffer the fish pond water. Fresh waters with permanently high pH are not common and very little can be done to make them more suitable for fish culture expect for the use of large quantities of alum or acid producing compound e.g. organic manure and compost.

Salinity

The term salinity refers to the total concentration dissolved ions in natural water expressed in part per million. The osmotic pressure of water increase with increasing salinity, fish species differs in their osmotic pressures requirements, so the optimum salinity for fish culture differs to some extents with species (Boyd 1973). Fish are highly sensitive to sudden change in salinity. Fish living in water at one concentration of salinity should not suddenly be placed in water with a much higher or lower salinity. Small fish and fry of most species are more susceptible than adults' fish to sudden changes in salinity.

Turbidity

The term turbidity indicates that a water contain suspended materials which intense with the passage of light. In fish pond, turbidity which results from planktonic organism is a desirable trait, whereas that cause by suspended clay particles is undesirable. Even with the latter condition, the clay particles are seldom abundant enough in water to directly harm fish (Boyd, 1981). The clay particles which remain in suspension restrict light penetration and limit the growth of plants in the pond. Turbidity is also an important water quality, which a fish farmer has to control. Turbid water has many particles suspended in it. These may also be plankton or suspended solid (Silt, clay/mud). It is therefore a measure of water transparency. Turbidity caused by plankton is not harmful to fish as and so beneficial to fish growth. Turbidity caused by suspended soil particles has direct effects on fish, but it restricts the amount of light penetrating the water and limit the photosynthesis and production of dissolved oxygen.

Pillay, (1992) observed that clay turbidity exceeding 20,000mg/liter causes behavioral reactions in many fish species and sedimentation of soil particles can also destroy benthic macro – invertebrates and smaller fish eggs. Therefore, suspended matters are not good for fish culture, this is because they can make fish pond water turbid to the extent of reducing the abundance of natural food available to fish, and they may also clog the fish gills, reducing resistance to diseases in fish, lowering growth rates, and affecting egg and larval development.

The best practical technique for measuring turbidity in fish pond water is to measure the secchi-disk transparency. This is the depth at which a disc 20cm in diameter with alternate black and white quadrants disappears from view. A secchi-dish transparency in the 30cm to 60cm range is generally adequate for good fish production (Boyd, 1979, Boyd and Lichkoppler, 1979; Ovie and Adeniji 1990).

Alkalinity

Alkalinity or total alkalinity is defined as the net negative change of all ions which react with the hydrogen ion. In natural waters, total alkalinity (mg/liter). Usually refers to the concentration of bases, which are primarily carbonate and bicarbonate ions. (Badiru 2005),Waters with high alkalinity have a high buffering capacity than waters with low alkalinity. Alkalinities of 30 to 150 mg/liter are preferred in fish culture operations (Dupee and Huner, 1994).

Hardness

Hardness is a measure of the amount of calcium and magnesium ions associated with carbonate. Total hardness is expressed in $mg1^{-1}$ equivalent C_aC0_3 and measures the total concentration of calcium and magnesium total hardness in fish pond water usually refers to the total concentration of divalent metal ions (Primary calcium, and magnesium), expressed in mg/liter of equivalent calcium carbonate. Hardness is not as critical to fish production of alkalinity but it is desirable to have water with a total hardness greater than 20mg/liter. The preferred range extends as high as 300mg per liter. (Boyd and Lichtkoppler, 1979)

Total alkalinity and total hardness are normally similar in magnesium, bicarbonates, and carbonate ions in water which are derived in equivalent quantities from the solution of limestone in geological deposits. If total alkalinity and total hardness are too low, they may be raised by liming. Badiru (2005), stated that, there is generally no practical way of decreasing total alkalinity and total hardness when they are above the desirable level.

Ammonia

Ammonia reaches pond water as a product of fish metabolism and decomposition of organic matter by bacteria, in water, ammonia nitrogen occurs in two forms; un-ionized ammonia (NH_3) and ammonium ion ($NH4^+$). Un-ionized ammonia is toxic to fish, but the ammonium ion is harmless except at extremely high concentration. The toxic level of unionized ammonia for short term exposure usually lies between 0.6 and 2.0 mg/liter for pond fish. The pH and temperature of the water regulate the proportion of total ammonia which occurs in un-ionized form. A pH increase 1unit cause roughly a tenfold increase in the production of un-ionized ammonia (NH_3) (Boyd, 1979).

The transformation is a function between the ionized and unionized form of ammonia is a function primarily of water pH and, to a lesser degree, water temperature.

$$NH^{+}_{4} + 0H^{-} \rightleftarrows NH40H \rightleftarrows NH_3 \rightleftarrows H_20$$

The equation moved to the right (i.e. the transformation of the ionized to the un-ionized form) with increasing pH and to a much lesser extent, with increasing temperature (Knud-Hansen, 2006).
The table below illustrates this relationship, showing the different percentages of unionized ammonia in the total ammonia pool with variable pH at 25 degree Celsius (Trussell, 1972; Emerson et al, 1975).

PH	NH_4^+	NH_3
5	100.0	0.0
6	99.9	0.1
7	99.4	0.6
8	94.7	5.3
9	64.2	35.8
10	15.1	84.9
11	0.8	99.2

This transformation has importance in aquaculture system, because unlike the ionized from, the un-ionized form can be highly toxic to culture organisms (Colt and Armstrong, 1981; Rufflier et al 1981; Meade, 1985).

Fortunately, ammonia concentration is seldom high enough in fish ponds to affect fish growth. The greatest concentration of total ammonia nitrogen usually occurs after phytoplankton die off at which time pH is low because of the high concentration of $C0_2$ (Boyd, 1979).

Hydrogen Sulphide: (H_2S)

Un-ionized hydrogen sulphide at concentration less than 1mg/liter may be rapidly fatal to fish. Low pH favors the presence of un-ionized hydrogen sulphide, and acid bodies of water which contain high concentration of hydrogen sulphide may be improved for fish culture by liming. Fortunately hydrogen sulphide is seldom factor in pond fish culture (Boyd, 1979). Un-ionized sulphides (e.g. H_2S) are extremely toxic to fish at concentrations that may occur in natural water. Bioassay of several species of fish suggests that any detectable concentration of H_2S should be considered detrimental to fish production. (Boyd, 1981)

CONCLUSION

Physicochemical parameters of pond water are very important in fish culture environment been the fact that it determines the goodness or badness of the water which, in turn serve as their physical support to carry out the life function such as feeding, excretion and reproduction. Finally, the paper should not be considered as the final information and answer to water quality management, but merely as suggestion on how to solve these problems.

REFERENCES:

Adeniji, H.A (1986): Some Limnological Precautions for fish farmer; fisheries enterprises and information Brochure in commemoration of the 5^{th} annual conference of the fisheries society of Nigeria.

Ajayi, O. (2004); A guide to primary productivity in fish pond management

Badiru, A.A (2005): Water quality management in aquaculture and fresh water zooplankton production for use in fish Hatcheries.

Boyd C.E (1973): The chemical oxygen of water and biological materials from pond. Trans Amer. Fish soc. 105:634

Boyd C.E (1979). Water quality in warm water fish ponds, Auburn Univ. Auburn, Alabama Res and Dev. Series No. 22

Boyd C.E and F. Lichtkoppler, (1979) water quality management in pond fish culture. International center for aquiculture, Agric Expt. Station Auburn University Alabama

Boyd C.E (1981) Water quality management for pond fish culture, Develop in aqua and fish 9 Elsevier Sci. public CO New York

Boyd C.E (1991). Water quality management for pond fish culture Alabama agric expt. Station, auburn university Alabama.

Colt and Armstrong (1981), nitrogen toxicity to crustacean's fish and mollusks in L.J Allen and E.C Kinney (Editors) Proceedings of the bio engineering symposium for fish culture, Fish culture section, American fisheries society, Bethesda, M.D PP 34 – 47.

Emerson KRC Russa R.E Lund and R.V Thurston, (1979), Aqueous ammonia equilibrium calculations effects on pH and temperature J. fish res. Board can, 32:2379 – 2383.

Knud-Hansen, (2006) Pond fertilization: Ecological Approach and practical applications

Meade, J.W (1985). Allowable ammonia for fish culture prog, Fish culture 47, (3): 135 – 145.

Ovie, S.J and H.A Adeniji (1990): A simple guide to water quality management in fish ponds. National Institute for Freshwater fisheries research technical report series No. 23:29

Ruffier, P.J W.C Boyd, and J. Klein Schmidt, (1981), short term acute bioassays to evaluate ammonia toxicity and effluent standards J. water Poll. Contr fed. 53:367 – 77

Trussell, R.P (1972). The percent un-ionized ammonia in aqueous ammonia solutions at different Ph levels and temperature J. Fish Res. Bd. Can. 29:1505 – 1507.

References to this paper should be made as follows: Kasim Lawal Ibrahim (2017), Physicochemical Parameters of Water and their Effects on Fish Production. *J. of Agriculture and Veterinary Sciences,* Vol. 9, No. 2, Pp. 20-31