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# Physico-chemical Properties Of Selected Fish Ponds In Nigeria: Implications for Artificial Fish Culture

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## Abstract

The need for baseline information on the suitability of fish pond environmental conditions for sustainable artificial fish culturing in Nigeria informed this study, on the physico-chemical properties of randomly selected typical fish ponds in the area. Methods: Series of water samples were collected from selected fish ponds at regular intervals, and subjected to physico-chemical analyses following recommended standard procedures. Results: The result indicated that certain parameters namely, Temperature, Turbidity, pH and Phosphates, varied within narrow limits among the 3 fish ponds investigated. However, Conductivity (range = 100.60 ± 32.01 to 338.00 ± 140.81 ), Alkalinity (132.40 ± 46.36 to 228.00 ± 28.88mg/l), Hardiness (39.60 ± 7.81 to 110.00 ± 16.25mg/l), Dissolved Oxygen (D.O.) (3.30 ± 0.77 to 6.66 ± 2.71mg/l), Biochemical Oxygen Demand (BOD) (0.84 ± 0.38 to 3.72 ± 1.95mg/l) and Nitrate (1.21 ± 0.68 to 9.24 ± 2.55mg/l) differed significantly ($P < 0.05$) in the ponds; and such differences were attributed to the influence of edaphic factors in different ecological settings. While pond ‘A’ had the highest values of physico-chemical parameter (except DO, BOD and Nitrate), Pond ‘B’ had the least in most of the parameters thus, perhaps, making the two ponds the most and least ideal for fish rearing, respectively. Conclusion: The values of the physico-chemical parameters obtained in this study were mostly within the recommended range for good fish production. The finding of this study should, therefore, serve as impetus to further encourage artificial fish farming in Minna, Nigeria, as away of meeting the growing demands for animal protein in the area.

## Introduction

The fish industry in Nigeria, typical of developing countries in general, is plagued with many challenges among which are poor knowledge of ideal management practices, nutritional and environmental requirements for optimum productivity. Kolo (1996) observed inadequate environmental conditions as one of the major factors that limit fish production. Such factors include water quality, relating to physical, chemical and biological properties of the ponds. Physical factors that are important in domestic fish farming include, shape and size of fish pond, types of substratal material, temperature, turbidity and pond transparency (Jonassen et al., 1999), while the chemical factors include, Dissolved Oxygen (DO) (Bond and Lichtkoppler, 1999; Mallya, 2007), alkalinity (Kemdirim and Adeniji, 1993), hardness of water, hydrogen ion concentration (pH), conductivity and mineral constituents such as nitrates and phosphates (Larry, 1995). In addition, there are biological factors which equally influence fish production; such factors include vegetation, predation and aquatic plants. Ovie and Adeniji (1993) reported that vegetation cover in fish ponds produced cooling effects and provided an array of micro-habitats, often necessary for spawning in fishes. Foran et al., (2005) noted that fishes are responsible for about 55% of protein intake of Nigerians. Unfortunately, most of these are obtained through traditional fish farming from the wild and partly through fish importation. The art of artificial fish culturing has not been adequately developed and the physical, chemical and biological environments of the fish ponds that are springing up have not been adequately studied and documented. This development necessitated the need for the present study. This work was, therefore, carried out to assess the physico-chemical properties of selected fish ponds in Nigeria, and to ascertain the suitability of such ponds for artificial fish culture.

## Methods

Study Area and Experimental Locations This study was carried in Minna metropolis, north central Nigeria. Minna is situated within Longitude 6o33’E and Latitude 9o 37’N. The climate of the area is tropical with a mean annual temperature of 30.20oC, relative humidity of 61.00%, and mean annual rainfall of 1334mm. The climate presents two distinct seasons: a rainy season between April and October, and a dry season from November to March every year. The highest mean monthly rainfall occurs in September while, the dry season is usually devoid of rains. Three major ponds were selected for this study namely, 1. FOLAB Fish Pond (Pond ‘A’): A backyard concrete pond with dimensions of 3.0m x 3.9m x 1.0m, and a stocking rate of 500 specimens of Clarias gariepinus. Water supply was through tap and well water. The tap water was collected in 2000 litres and allowed to stand for 48 hours before use. Feeding was done through the supply of both artificial and natural feeds. In addition, there was light vegetation made up of umbrella trees, mango, and guava trees complemented by shrubs such as banana plants, around the pond. 2. FUT Fish Pond (Pond ‘B’): Another concrete fish pond with a dimension of 4.9m x 9.0m x 1.5m, and stocking rate of 1000 specimens of Tilapia niloticus. Feeding was also through both natural and artificial means. The source of water was through a nearby river. Adjacent to this pond was also light vegetation cover made of shrubs like banana and trees such as mango. 3. MUSGOLA Fish Pond (Pond ‘C’): An earthen pond with dimensions of 13m x 6.5m x 1.2m, and stocking density of 1000 specimens of Clarias gariepinus. The fishes were also fed natural and artificial feeds. Water Sample Collection A known quantity of water was collected in a plastic container and an oxygen bottle at the various ponds. The atmospheric temperature was measured before water collection and immediately after the water was put in various containers, using a mercury thermometer. The oxygen bottles were filled to the brim at sampling stations and fixed with 1ml Manganese Sulphate solution (Reagent 1) and alkaline iodide azide solution (Reagent 2). The samples were then taken to the laboratory for analysis Water Quality Analysis (a) Temperature: The temperature of the water samples was determined on the spot using an ordinary mercury thermometer (6cm Immersion, Collehhamp England), and promptly recorded. (b) Transparency: Transparency of the water was measured using Secchi disc (Griffin George, London). The disc was carefully lowered into the water bodies, and the depth at which it disappeared from sight was recorded as d1. The disc was then raised up gently, and the depth at which it comes into view was noted as d2. The average of the two readings (i.e., d1 and d2) was taken as the transparency of the water bodies in centimeter (cm). (c) Conductivity: Electrical conductivity of the water samples was determined using Conductivity Meter (LUTRON CD-4303, Taiwan). The procedure used involved connecting the Meter to electricity and dipping it into 100 ml beaker of each pond water sample. The probe was properly dried up before the readings were taken. (d) Dissolved Oxygen (DO): Dissolved Oxygen was determined using the Winkler Azide method as described by Dunivant (2005) and the American Public Health Association (APHA) (1980). This involved fixing the water samples in the field with Manganese Sulphate and alkaline-azide solutions (i.e., reagents 1 and 2, respectively). The samples were analyzed to set free Manganese ion (Mn2+) after adding 2ml concentrated Sulphuric acid (BDH, England). About 10ml of each sample was then titrated with 0.025N Sodium thiosulphate (BDH, England), using starch solution as indicator. Titration continued until the blue colouration became colourless. Dissolved Oxygen was then expressed in mg/l. (e) Hydrogen ion Concentration (pH): The pH of the sample was determined using pH meter (JENWAY, U.K.). About 100ml water was taken in a beaker. The pH meter was then immersed in each water sample and connected to electricity and pH electrode after standardization. The electrode was immersed in a buffer solution, rinsed in distilled water and dried up with tissue paper before readings were taken for the various samples. (f) Alkalinity: Water alkalinity was measured by adding 2 to 3 drops of methyl orange indicator to 50ml of water in a clean conical flask. The resultant mixture was titrated with 0.02N Sulphuric acid ((BDH, England)), until the colour changed from yellow to orange. Alkalinity was then expressed in mg/l. (g) Water Hardness: Into a 250ml beaker of water, was added 1ml Ammonium Chloride buffer solution (BDH, England). The mixture was properly stirred together. To this mixture was added 0.2ml Eriochrome black T indicator (BDH, England) and mixed thoroughly. The resultant wine colour was then titrated with 0.01N Ethlene-diamine-tetraethonic acid (EDTA) solution, until a blue end point was observed. Water Hardness was then expressed in ml/l (h) Biochemical Oxygen Demand (BOD): Biochemical Oxygen Demand (BOD) was determined by first determining the Dissolved Oxygen of the water samples on the first day and the same sample was incubated at room temperature for 5 days in the dark before titration for oxygen using Winkler-azide method (APHA,1980). The BOD expressed in mg/l, was obtained by taken record of the initial Dissolved Oxygen reading (day 1) and dissolved oxygen reading after the period of the incubation (day 5). So, BOD (mg/l) = DO on day 1 – D.O on day 5. (i) Phosphate–Phosphorus: Phosphate was determined via 2 stages, i.e., digestion (Sulphuric acid /nitric acid method) after which the phosphate was determined by ascorbic acid method (APHA, 1980). In the Sulphuric acid-Nitric acid digestion, 200ml of water samples were measured into 250 ml conical flask, while 1ml of concentrated Sulphuric acid (BDH, England) and 5ml concentrated Nitric acid (BDH, England) were then added. The solution was digested to a volume of 1ml on a hot plate and continued until the solution became colourless signifying a total removal of nitric acid. In the ascorbic acid determination of Phosphorus, the digest was allowed to cool after which 10ml distilled water was added. About 1ml Phenolphthalein indicator was added to the solution and the acid was neutralized by adding as much Sodium Hydroxide required to produce a faint pink colour. About 6mm of combined reagent (made up of 5ml NH2S04, 5ml Potassium Antimonyl solution, 15ml Ammonium Molybdate and 30ml ascorbic acid) was added to the solution. The solution was then made up to the 50ml mark with distilled water and the absorbance of each sample was measured at 880NM on a spectrophometer, using reagent balance as the reference solution. Phosphate-phosphorus of the sample was then read from the calibrated curve. Nitrate Nitrogen: The Phenoldisulphonic acid method was used as described by Paerl et al. (1975). About 50ml of water sample was evaporated to dryness followed by the addition of 1ml Phenoldisulphonic acid (BDH, England) to the residue and left for 10 minutes. About 10ml of distilled water was then added followed by 5ml of Sodium Hydroxide (BDH, England). The resultant yellow mixture was stirred and allowed to cool. The absorbance was measured at 450NM on spectrophotometer. The nitrate-nitrogen of the samples was then read from the calibrated curve. Statistical Analysis: The statistical analysis of data collected was done using chi-square to determine the variation of physic-chemical parameters from among the ponds. Different types of range tests were used to compare means of parameters among the different ponds according to Turkey test (Steel and Torrie, 1963).

# Results

Table 1 shows relative comparison of physico-chemical properties of the ponds (i.e., A, B, and C) investigated. Mean water temperature ranged from 26.72± 1.65°C in pond A to 27.92± 0.99°C in the other two fish ponds, results not significantly different (P > 0.05) among the three ponds. A similar non-significant (P > 0.05) difference was also observed in the results of turbidity measurements. However, water conductivity, alkalinity and hardness concentrations varied significantly (P < 0.05) among the ponds. Among the three Ponds, ‘A’ had the highest water conductivity (338 ± 140.81), alkalinity (228 ± 28.88mg/l) and water hardness (110.00 ± 16.25mg/l), while the least values of these physic-chemical factors were recorded in fish Pond B (100.60.32, 132.40 ± 46.36mg/l and 39.60 ± 7.81mg/l, respectively).

The results in Table 2 show that there were no significant (P > 0.05) differences in the concentrations of $p^H$ and phosphates in the three ponds. However, the levels of Dissolved Oxygen (6.66 ± 2.71mg/l) and Biochemical Oxygen Demand (3.72 ± 1.92mg/l) were highest in Pond B. Nitrate concentration was highest in pond C and least in B. It appeared that the salts (i.e., nitrates and phosphates) were highest in pond C than the other two ponds while, the gases (i.e., Dissolved Oxygen and Biochemical Oxygen Demand) were most concentrated in pond B. Pond A did not show consistency in the trend of any group of physico-chemical parameters in Table 2. The most varied physico-chemical parameter in the ponds was nitrate, which ranged from 1.27 ± 0.68 to 9.24 ± 2.55mg/l.

# Discussion

The variations observed in the physico-chemical properties of the three fish ponds studied could be attributed of the influences of the micro-climatic, topographic and edaphic conditions of fish ponds in the area. The temperature range of 26.72 ± 1.65 to 27.92 ± 0.99°C obtained in the ponds was within the recommended temperature range for optimum fish performance in this area. Afzal et al. (2007) recommended a temperature range of between 25°C and 32°C for good performance of fishes. The highest temperature recorded in Pond C was not unexpected because the station had the highest exposure to sunlight and the least shading affect of banana trees and shrubs around the pond. The least temperature (25.5°C) observed in Pond A could be attributed to the shade effect of the banana trees around the pond. The dissolved oxygen (DO) ranged from 3.30 ± 0.77 in Pond A to 6.66 ± 2.71mg/l in pond B. These results show that fishes in Pond A may not be having adequate Dissolved Oxygen supply compared to those in ponds B and C. According to Ufodike and Garba (1992) a minimum constant value of 4.0mg/l D.O. is adequate for most species and stages of aquatic life. Pond A had 3.30 ± 0.77mg/l Dissolved Oxygen. The low D.O. obtained in pond A may be attributed to the smaller size of the pond and eutrophication due to over fertilization with poultry manner. The high D.O. observed in pond B (6.66 ± 2.71mg/l) may not be unconnected with atmospheric re-aeration by wind and a continual discharge of water from the inlet pipes: The $p^H$ range of 7.06 - 7.14 recorded in the fish ponds falls within the recommended $p^H$ range of 6.5 – 8.5 Sterling and Philips (1990) for good fish performance.

The values obtained for water hardness in the ponds (i.e., 39.60 ± 7.81 to 110.00 ± 16.25mg/l) are within range recommended for good fish production (Mateen, 2004). The author stated that the desirable level of total hardness concentration should be similar to total alkalinity in most water. Fish Pond A which is the hardiest water appeared to be more productive biologically than the soft water.

The high BOD in Pond B may be attributed to the presence of decay process in the pond while the low BOD in Ponds A and C could be due to little or no organic matter degradation. Brunson et al. (1994) observed that in productive inland water bodies in Africa, Nitrate or Nitrogen levels range from 9.8 - 49mg/l while, phosphate phosphorus range between 3.2 and 6.30mg/l. This indicates that the average values of nitrates in the three ponds, i.e., 3.8mg/l, 1.2mg/l and 9.2mg/l, respectively, may adequately support aquatic productivity.

The differences observed in both conductivity and alkalinity among the 3 ponds could be due to the influences of prevailing edaphic factors, particularly the substratum, as the three ponds were located widely apart in different ecological settings of the study area. Wurts and Durborow (1992) gave the ideal alkalinity range for fish production to be between 20 and 30mg/l. The alkalinity observed in the three ponds were thus within this range. Earlier, Kolo (1996) reported a conductivity range of 120 - 340s for fish ponds in the area; results that agreed substantially with those of this study.

**Conclusion**

The results of this study showed that Pond A had the highest values of all physico-chemical parameters studied except D.O., BOD and nitrates. The high physico-chemical properties of Pond A might have contributed to the hardness of the water thereby making it to be more productive biologically than other ponds. Pond B had the least values of certain parameters namely, conductivity, alkalinity, water hardness and nitrate levels; Thus. Pond C appeared to be better than B and should be recommended next to pond A for fish production. The values of most of the physico-chemical parameters investigated in this study, were within the range recommended for good fish production, indicating that the environmental conditions in Minna offer conducive conditions for fish survival and growth hence, increased productivity from fish ponds. This finding should serve as impetus to further encourage artificial fish farming in the area.

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# Illustrations

## Illustration 1

Mean values of Physico-chemical properties of selected fish ponds in Nigeria

| Fish Pond | Temperature ($^oC$) | Turbidity (mg/l) | Conductivity () | Alkalinity (mg/l) | Hardness (mg/l) |
|---|---|---|---|---|---|
| **A** | 26.72 ± 1.65$^a$ | 0.22 ± 0.15$^a$ | 338.00 ± 140.8 $^a$ | 228.00 ±2 8.88$^a$ | 110.00 ± 16.25$^a$ |
| **B** | 27.92 ± 0.86 $^a$ | 0.23 ± 0.07 $^a$ | 100.60 ± 32.01$^c$ | 132.40 ± 46.36$^c$ | 39.60± 7.81$^c$ |
| **C** | 27.92 ± 0.99 $^a$ | 0.16 ± 0.11 $^a$ | 214.80 ± 84.23$^b$ | 190.00 ± 42.24$^b$ | 69.20 ± 9.32$^b$ |

Column means with the same superscripts do not differ significantly (p>0.05) from each other. Each means is an average of 5 samples

# Illustration 2

Means values of Physico-chemical properties of selected fish ponds in Nigeria

| Fish Pond | pH | D.O. (mg/l) | B.O.D (mg/l) | Phosphates (mg/l) | Nitrate (mg/l) |
|---|---|---|---|---|---|
| A | 7.06 ± 0.43[a] | 3.30 ± 0.77[c] | 0.84 ± 0.38[a] | 0.01 ± 0.00[a] | 3.88 ± 0.83[b] |
| B | 7.14 ± 0.28[a] | 6.66 ± 2.71[a] | 3.72 ± 1.95[a] | 0.01 ± 0.00[a] | 1.27 ± 0.68[c] |
| C | 7.14 ± 0.52[a] | 4.72 ± 2.62[b] | 1.37 ± 0.71[b] | 0.90 ± 0.04[a] | 9.24 ± 2.55[b] |

D.O. = dissolved oxygen
BOD = Biochemical Oxygen Demand.
Each means is an average of 5 samples
Means in the same column with the same alphabet do not differ significantly ($p>0.05$).