

## DYNAMICS OF WATER QUALITY IN TROPICAL EARTHEN FISH PONDS

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### Abstract

Aspects of physicochemical parameters of three fish ponds in Michael Okpara University of Agriculture, Umudike were studied between February 2015 and January 2016, to evaluate its suitability for optimum fish productivity. The results were as follows: water temperature (24.1 - 34.0 °C), depth (52.0 - 115.0 cm), transparency (30.4 - 38.2 cm), pH (6.3 - 10.8), conductivity (44.0 - 190.0 µS/cm), Total Dissolved Solids (35.1 - 98.0 mg/l), Dissolved Oxygen (3.7 - 5.1 mg/l), Biochemical Oxygen Demand (1.3 - 2.8 mg/l), nitrate (16.7 - 34.3 mg/l) and phosphate (0.01-3.33 mg/l). All the physico-chemical parameters evaluated were within the acceptable range set by NESREA except pH. The depth (water level) was found to be inadequate based on previous studies. In conclusion, the water quality characteristics assessed in the fish ponds were observed to be suitable for optimum fish productivity except for pH and depth (water level).

**Keywords:** physico-chemical parameters, aquaculture, productivity

### Introduction

Fish remains among the most traded food commodities worldwide (FAO, 2014). Fish is estimated to contribute about 60% of the world supply of protein and 60% of the developing countries derives more than 30% of their animal protein from fish (Adebayo-Tayo *et al.*, 2010). Fish, which constitute one of the cheapest sources of animal protein is generally appreciated as one of the healthiest source of protein because it has amino acid compositions that are higher in cysteine than most other source of animal protein (Zenebe *et al.*, 1998). Fish production in aquaculture is now on the increase as a result of high demand of fish food and over exploitation of fishes in the wild (Saanu *et al.*, 2017) and need to address the shortfalls in capture fisheries (Tidwell and Allan, 2001). Frid and Paramor (2012) reported that aquaculture is an increasingly important source of food globally. The success or failure of any aquacultural venture depends on the water quality (Piper *et al.*, 1982). Water quality in fish pond is often due to the interactions of several physico-chemical components and can have a profound effect on pond productivity and the level of fish health (Boyd, 1982). The importance of water to living things cannot be over emphasized. It is believed to be the reason for life of earth because all living things depend on water for its existence (Parariya, 2012). The production of fish is directly dependent on the productivity of the entire pond water ecosystem namely, the abundance of both phytoplankton and zooplankton in a pond provides fish with ample natural foods by which fish can grow fast and increase yield (Bhatnagar and Devi, 2013).

The existence of large biomass of plankton is also favoured by suitable physico-chemical factors, hence in fish culture, water quality and the success in its management depends on a strong knowledge of the structure and functioning of the ponds particularly with regards to the water's physical and chemical variables and to the biological communities (Bhatnagar and Devi, 2013). Changes in the physico-chemical parameters may positively or negatively affect the reproduction, survival and growth rate of biota of water bodies and may eventually lead to the extinction of organisms (Edward and Ugwumba, 2010). Physico-chemical parameters of any water body are known to change overtime; hence this study was carried out to evaluate aspects of the physico-chemical parameters of the fish ponds in the University fish farm to ascertain their suitability for optimum fish productivity.

### Study Area

Michael Okpara University of Agriculture, Umudike, Nigeria is located in Ikwuano Local Government Area of Abia State within latitude 5°28'N to 5°29'N and longitude 7° 31'E to 7° 32'E. The fish farm is close to the College of Natural Sciences Complex and the ponds were demarcated by a farm road (Fig.1). The substrates of the ponds are muddy with aquatic macrophytes around the edges of the ponds. African Mud Catfish, *Clarias gariepinus* and *Tilapia zilli* are the common fishes raised in the ponds.

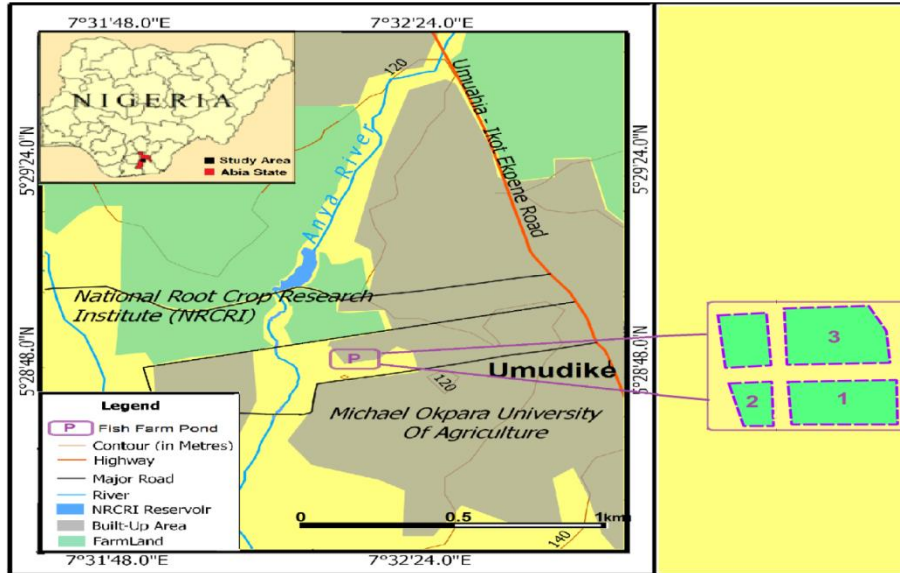


Fig. 1: Location of the Fish Ponds in Michael Okpara University, Umudike, Nigeria.

## Materials and Methods

### Sample Collection and Analysis

The ponds were sampled monthly for 12 months (February 2015 to January 2016) between 9am and 2pm. One litre water sampler was thoroughly rinsed with the water sample before collection. *In situ* measurements were carried out for temperature (mercury-in-thermometer), depth (graduated wooden pole), pH (ISE Hanna pH meter), transparency (Secchi disc), dissolved oxygen (DO), electrical conductivity and total dissolved solids (TDS) (Hanna Multiparameter). Other parameters were determined in the laboratory: Biochemical oxygen demand (BOD) (Winklers' method), nitrate (Hach DR 1900 UV Spec) and phosphate (Stannous Chloride Method) (APHA, 1985).

### Statistical Analysis

All the results were statistically analysed using ANOVA and Least Significant Difference (LSD) test was performed to determine the location of significant differences (Ogbeibu, 2005).

### Results

The physicochemical parameters of the ponds are summarized in Table 1. Water temperature ranged from 24.1 to 34.0°C. The lowest temperature value was recorded in pond 3 in February 2015 while highest was recorded in Pond 1 in July 2015. The pond depth ranged from 58.2cm to 81.75cm. The lowest depth was recorded in pond 3 in February 2015, while the highest value of was recorded in pond 2 in July 2015. Depth was significantly different in all the ponds ( $F= 21.75, p<0.001$ ).

Transparency value of the water ranged between 30.4 cm and 38.2 cm. The lowest transparency value was recorded in pond 1 in February 2015 while the highest was recorded in pond 3 in July 2015. The pH values of the water were moderately acidic to moderately alkaline with a range of 6.3 to 10.8. The lowest pH was recorded in pond 3 in February and September 2015, while the highest value was recorded in pond 1 in April 2015. Electrical conductivity values ranged from 44.0 to 190  $\mu\text{S}/\text{cm}$ . The lowest value was recorded in pond 2 in July 2015 while the highest value was recorded in pond 1 in April 2015. Electrical conductivity also was significantly different in all the ponds ( $F= 39.97, p<0.001$ ). Total dissolved solid (TDS) values ranged from 35.1 to 98.0 mg/l. The lowest value was recorded in July while the highest was recorded in December 2015, both in pond 2. The dissolved oxygen content ranged between 3.7 and 5.1 mg/l. The lowest DO value was recorded in October 2015 in pond 1 while the highest values were recorded in pond 1 (February and July 2015), pond 2 (March 2015) and pond 3 (June 2015). The lowest value of  $\text{BOD}_5$  ( $1.3\text{mg/l}^{-1}$ ) was recorded in pond 3 in August 2015 while the highest value of 2.8 mg/l was recorded in July 2015 in pond 1. The lowest and highest nitrate values of 16.7 and 34.4 mg/l respectively were recorded in pond 1 (February 2015) and pond 2 (July 2015). The phosphate ( $\text{PO}_4$ ) values were relatively low, ranging from 0.01 to 3.33 mg/l. The lowest phosphate values were recorded in pond 2 (February 2015) and pond 3 (March 2015) while the highest value was recorded in pond 1 in February 2015.

**Table 1: Summary of physico-chemical parameters of the university fish pond (with range in parenthesis)**

Physical parameters	Pond 1 $\bar{x} \pm S.E$	Pond 2 $\bar{x} \pm S.E$	Pond 3 $\bar{x} \pm S.E$	P-value	NESREA
<b>Water Temperature (°C)</b>	27.87±0.90 (25.3-34.0)	26.40±0.29 (24.6-28.5)	26.08±0.37 (24.1-27.9)	$P > 0.05$	< 40
<b>Depth (cm)</b>	72.50±1.49 (65.0-80.0)	81.75±3.93 (62.0-115.0)	58.20±1.29 (52.0-68.0)	$P < 0.001$	-
<b>Transparency (cm)</b>	33.81±0.69 (30.4-37.0)	34.72±0.64 (30.5-37.2)	34.74±0.75 (30.8-38.2)	$P > 0.05$	-
<b>Ph</b>	8.19±0.40 (6.7-10.8)	7.75±0.35 (6.4-10.0)	7.04±0.21 (6.3-8.5)	$P > 0.05$	6.5 - 8.5
Chemical parameters					
<b>Conductivity (µs/cm)</b>	157.18±4.97 (138.2-190.1)	79.67±6.49 (44.0-113.0)	116.00±6.79 (78.0-152.0)	$P < 0.001$	-
<b>Total Dissolved Solids (Mgl<sup>-1</sup>)</b>	66.29±2.59 (52.1-86.5)	63.77±6.06 (35.1-98.0)	69.38±2.12 (55.5-86.5)	$P > 0.05$	2000
<b>Dissolved Oxygen (Mgl<sup>-1</sup>)</b>	4.38±0.15 (3.7-5.1)	4.58±0.90 (4.2-5.1)	4.78±0.06 (4.2-5.1)	$P > 0.05$	4
<b>BOD<sub>5</sub> (Mgl<sup>-1</sup>)</b>	2.24±0.08 (1.8-2.8)	2.05±0.03 (1.9-2.2)	1.99±0.11 (1.33-2.5)	$P > 0.05$	10
<b>Nitrate (Mgl<sup>-1</sup>)</b>	23.12±1.39 (16.7-32.2)	22.20±1.48 (17.2-34.3)	22.43±1.81 (17.3-34.1)	$P > 0.05$	20
<b>Phosphate (Mgl<sup>-1</sup>)</b>	0.78±0.36 (0.05-3.33)	0.09±0.01 (0.01-0.18)	0.51±0.26 (0.01-3.1)	$P > 0.05$	5

NESREA – National Environmental Standards and Regulation Enforcement Agency (2011).

## Discussion

All living organisms have tolerable limits of water quality parameters in which they perform optimally (Bhatnagar and Devi, 2013). A sharp drop or an increase within these limits has adverse effects on their body functions (Kiran, 2010). So, good water quality is very essential for survival and growth of fish. The physico-chemical parameters of the ponds showed minimal variations. Water temperature affects a multitude of important processes in aquaculture. Physiological processes in fish such as respiration rates, feeding, metabolism, growth, behaviour, reproduction and rates of detoxification and bioaccumulation are affected by temperature (Bolorunduro and Abdullah, 1996; Zweig *et al.*, 1999). Bhatnagar and Devi (2013) reported that temperature range of 20 – 30 °C is desirable for optimum fish production while Adeniji and Ovie (1982) and Madu (1989) reported that the best temperature range for optimum production of *Clarias* species is 25 - 31°C; one of the fish species cultured in the University Fish Farm. Some of the values recorded in this study were higher than these ranges and could be attributed to lack of vegetation cover around the ponds. Eze and Ogbaran (2010) recorded a high temperature range of 30.02 – 30.10 °C in Ughelli while Solomon Wisdom et al (2013) recorded lower ranges of 24.0 – 29.0 °C in Abuja,

Nigeria. The temperature range showed that the pond water was good for fish production.

Water depths (water level) recorded in this study were generally low (<1m) but increased with the rains. The low water depths could be attributed to evaporation especially during the dry season and not conducive for optimum fish production. The depth of water in ponds has an impact on the productivity of ponds. Fynn (2015) reported that “as depth increased, Productivity increased as well up to a depth of approximately 1 m”. He went further to say that “For fish ponds to be productive, the acceptable pond depth should be between 1 and 2 meters as at this depth, the chances of aquatic vegetation problems are reduced significantly”. The depth of ponds has an effect on the growth, feeding habits and mortality rates of fish (El-Sayed *et al.*, 1996; Ali *et al.*, 2013). Stress on fish, fungal infections and mortality rates of fish all increased in shallow water depths due to reduced feeding activity and low metabolic energy in a study conducted in Egypt (El-Sayed *et al.*, 1996). Beyond the preferred temperature range of cultured fish, the fish tend to move away from the surface to seek refuge in deeper waters (El-Sayed *et al.*, 2006). It is therefore essential for fish ponds to be deep enough to meet both the habitat and temperature requirements of farmed fish. This explains why

shallower water depths were strongly correlated with low productivity (Fynn, 2015). Teodorowicz (2013) also observed that decreasing water levels agitate fish, and they respond with rapid movements that disturbs the clay bottom deposits; such disturbances affect the turbidity, transparency and organic content of the ponds.

The pH can also affect fish health. For most freshwater species, a pH range of 6.5 - 9.0 is ideal (PHILMINAQ, nd; Bhatnagar and Devi, 2013). Below pH 6.5, some species experience slow growth and at lower pH, the organism's ability to maintain its salt balance is affected and reproduction ceases (Lloyd 1992). On the other hand, high pH levels can make the toxic form of ammonia become more prevalent, and the phosphate, which is commonly added as a fertilizer, can rapidly precipitate (Boyd, 1990). The pH values recorded in this study are within the value of optimum fish production and in the same range with Eze and Ogbaran (2010) and Keremah *et al.*, (2014) while Solomon Wisdom *et al.* (2013) recorded values outside the ideal range (5.43 – 10.14) in Abuja, Nigeria.

Water transparency expresses the level of productivity of a water body (Parven *et al.*, 2013). The transparency values recorded in this study indicated that the ponds are productive. Boyd (1982) and Wahab *et al.*, (1994) reported that the transparency of productive water bodies should be 40 cm or less.

Electrical Conductivity (EC) is an index of the total ionic content of water, and therefore indicates freshness or otherwise of the water (Ogbeibu and Victor, 1995). Conductivity can be used as indicator of primary production (chemical richness) and thus fish production (Bhatnagar and Devi, 2013). James (2000) reported that a freshwater body supporting good mixed fisheries has a range of EC between 150 and 500  $\mu\text{S}/\text{cm}$ . Conductivity values recorded in this study were generally lower and within this range especially ponds 1 and 3. This could be attributed to depth because increase in water levels dilutes mineral concentrations as in pond 2 with higher mean water depth. Munni *et al.* (2013) recorded higher EC values of 138 - 274  $\mu\text{S}/\text{cm}$  in Bangladesh and Solomon Wisdom *et al.*, (2013) also recorded higher EC values (72 - 478  $\mu\text{S}/\text{cm}$ ) in Abuja, Nigeria.

The Total Dissolved Solids (TDS) values of all the studied ponds were low and within the acceptable limits. In fish culture, a maximum TDS value of 400 mg/l is permissible for diverse fish production (James, 2000). Eze and Ogbaran (2010) and Agbaire *et al.*, (2015) recorded lower values of 16.08 - 27.41 mg/l and 19.19 - 24.25 mg/l in Ughelli and Abraka areas of Delta State, Nigeria respectively while Munni *et al.*, (2013) recorded TDS values (85 - 164

mg/l) that is within our range in Bangladesh and Ehiagbonare and Ogunrinde (2010) recorded a range of 22 - 960 mg/l in Okada area of Edo State, Nigeria.

Dissolved oxygen (DO) is considered as one of the most important aspect of aquaculture. Dissolved oxygen affects the growth, survival, distribution, behaviour and physiology of shrimps and other aquatic organisms. Low levels of dissolved oxygen are often linked to fish kill incidents. On the other hand, optimum levels can result to good growth, thus result to high production yield (PHILMINAQ, nd). Low DO values were recorded in this study, which could be attributed to high temperature, low atmospheric pressure and high humidity in wet season. Bhatnagar *et al.* (2004), Saloom and Duncan (2005) and Bhatnagar and Singh (2010) reported that DO level  $>5$  mg/l is essential to support good fish production. Munni *et al.*, (2013) reported a DO range of 1.1-6.9 mg/l in Bangladesh while Solomon-Wisdom *et al.*, (2013) also recorded higher DO values (5.43 – 8.86 mg/l) in Abuja, Nigeria.

Biochemical Oxygen Demand (BOD) is an important parameter of water indicating the health scenario of freshwater bodies (Bhatti and Latif, 2011). The BOD<sub>5</sub> values recorded in this study were low and values of between 3.0 to 6.0 mg l<sup>-1</sup> have been reported as optimal for normal fish activities (Bhatnagar *et al.*, 2004). Fallen leaves, and debris, and waste product of fishes, other insect population within the pond (Solomon-Wisdom and Olatunde 2014) and eutrophication resulting from unused feed present in water can cause possible increase in BOD (Curtis 1988; USDA 1996). Increased BOD can threaten the survival of fish and other aquatic organisms (Curtis, 1988). Munni *et al.*, (2013) reported a BOD range of 1.4 – 4.2 mg/l in Bangladesh while Solomon-Wisdom *et al.* (2013) also recorded lower values (0.47 – 2.96 mg/l) in Abuja, Nigeria.

Nitrate is the least toxic of the major inorganic nitrogen compounds. It is formed as the end product of the nitrification process and concentrations are generally higher than both ammonia and nitrite (Zweig, 1999) and are normally stabilized in the 50-100 mg/l range (Bhatnagar and Devi, 2013). The Nitrate values recorded in study was high but within acceptable limits and exhibited seasonal variation; with higher values recorded during the wet season. The high concentration could be attributed to fish waste, unconsumed feed and fertilization. According to Stone and Thomforde (2004), nitrate is relatively nontoxic to fish and not cause any health hazard except at exceedingly high levels (above 90 mg/l). Santhosh and Singh (2007) described the favourable range of 0.1 - 4.0 mg/l in fish culture water. Related studies recorded very lower values (Ehiagbonare and

Ogunride 2010; Eze and Ogbaran 2010; Agbaire *et al.*, 2015).

Phosphate is a limiting nutrient needed for the growth of all plants- aquatic plants and algae alike. However, excess concentrations especially in rivers and lakes can result to algal blooms (PHILMINAQ, nd). The Phosphate values recorded in this study were generally low though higher during the dry season especially in ponds 1 and 3 and within acceptable limits. According to Stone and Thomforde (2004) the phosphate level of 0.06 mg/l is desirable for fish culture while Bhatnagar *et al* (2004)

suggested 0.05 - 0.07 mg/l is optimum and productive. The values recorded in this study is of the same range with related studies carried out in Nigeria (Ehiagbonare and Ogunride 2010; Eze and Ogbaran 2010; Agbaire *et al.*, 2015).

### Conclusion

The water quality characteristics assessed in the university fish ponds were observed to be suitable for optimum fish productivity except pH and depth (water level).

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