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An Assessment of Dry Season Fish Mortality and Water Quality of Selected Fish Ponds in Two Area Councils of the Federal Capital Territory, Nigeria

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Abstract – **The levels of the physicochemical regime and fish mortality of two selected fish ponds in Gwagwalada and Kuje Area Councils of the Federal Capital Territory were determined from November to January (dry season), by using standard methods and equipment. The values of physico-chemical parameters of both fish ponds in Gwagwalada and Kuje respectively during the dry season ranged from 101.50 ± 9.71 to 193.50 ± 17.12ppm (alkalinity), 1.26 ± 0.50 to 2.79 ± 0.63 mg/L (BOD), 100 ± 4.69 to 320.50 ± 37.69µs/cm (Conductivity), 3.05 ± 0.60 to 4.26 ± 0.85 mg/L (DO), 6.58 ± 1.53 to 9.38 ± 0.65 (pH), 26.75 ± 0.43 to 31.00 ± 2.45°C (temperature) and 1.90 ± 0.43m to 2.88 ± 0.22m for turbidity. There was no significant difference ($p > 0.05$) in the levels of physico-chemical parameters between the fish ponds in Gwagwalada and Kuje in the dry season. Fish pond A Kuje had the highest fish mortality 728 (36.40%) and fish pond B Gwagwalada had the highest 955 (63.67%). Fluctuation in physicochemical parameters and fish mortality were strongly and positively correlated ($r = 0.5, 0.7, 0.9$ and 1.0) in all these ponds. Fish mortality rate was also significant ($p< 0.05$) in all ponds. Most of the physicochemical parameters were also strongly correlated with one another. The essence of monitoring water quality in fish ponds to prevent adverse impact on water quality is also highlighted.**

Keywords – **Fish Ponds, Physicochemical, Monitoring, Fish Mortality, Water Quality, Dry Season.**

I. Introduction

Fish and other organisms live in water. Thus, It is no surprise that professional fish culturists state that "water quality determines to a great extent the success or failure of a fish culture operation" (21). Water quality includes all physical, chemical and biological factors that influence the beneficial use of water. A pond with good water quality will produce more and healthier fish than a pond with poor quality water (6).

Some of the physico-chemical parameters that are regularly measured within an aquaculture pond include dissolved oxygen, alkalinity, hardness, pH, conductivity, temperature, turbidity and biological oxygen demand (BOD). Water qualities in ponds changes continuously and are affected by each other along with the physical and biological characteristics (32).

Water quality is frequently a prominent concern where aquaculture is practiced. Maintaining a healthy environment is not only important to the organisms being cultured, but also, to the flora and fauna that are indigenous to the site, as well as the migratory species that circulate through and around the site (10). Maintaining a good water quality in aquaculture ponds will require effective monitoring to detect changes in environmental quality that results from aquaculture operations.

Despite, the existing studies (2; 15; 8; 23; 27; 24; 31) on some natural water bodies with respect to water quality, information about these critical water quality parameters in fish ponds are scanty in many areas of Nigeria, particularly in the Federal Capital Territory where there is a rise of this fledgling industry. The Federal Capital Territory needs to develop reliable information on water quality in aquaculture. This information is necessary to enhance the development of a balanced, comprehensive and effective policy which will promote aquaculture enterprises.

Monitoring of water quality can quantify the scope and duration of fish culture. Early identification of water quality degradation through routine monitoring permits aqua culturists to implement minor operational changes to correct identified problems before it reaches an extreme condition.

Early identification of environmental problems prevents cumulative environmental degradation which may save the life of cultured organisms. When degradation reaches an extreme level, cultured organisms experience depressed growth rates, increased disease conditions and even death. This is adreadful situation for fish farmers.

Some water quality factors that are more likely to be implicated with fish losses include dissolved oxygen, temperature and ammonia. Others, such as pH, alkalinity, hardness and clarity can affect fish, but usually not directly toxic (26). Each water quality factor interacts with and influences other parameters, sometimes in complex ways (19). The determination and frequency of monitoring water quality depends upon the rearing intensity of the production system used.

Turbidity determines light penetration in water. This in turn will have an effect on the temperature of the water and the amount of vegetation and algae that will grow in the pond, thus affecting the rate of photosynthesis and primary productivity (32; 10).

The determination of these parameters will provide useful information to farmers in raising fish at a site for long period of time while minimizingimpact to the environment.

II. Description of Study Area

The study areas are Gwagwalada and Kuje Area Councils of the Federal Capital Territory. Gwagwalada Area council lies between latitude $8^0$55'N and $9^0$00'N and longitude $7^0$00'E while Kuje Area Council lies between latitude $7^0$05'N and $9^0$10'N and longitude $9^0$15'E (16).

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III. Sampling and Methodology

Simple randomized sampling method was used in collection of water samples. Concrete fish ponds were selected based on size and consistency of stocking the ponds. Samples were collected from two fish ponds located in each of the Area Councils from November to January 2009 in the dry season. Sampling was done four times in a month (i.e once every week) for each of the fish ponds. The features of the pond such as depth, length and breadth were taken using a metre rule once at the beginning of sampling before determination of physico-chemical parameters. Other important information about the ponds such as source of water supply, period or length of use was obtained by interview and through questionnaire.

IV. Determination of Physico-Chemical Parameters

The modified Winkler method (3) was used to determine dissolved oxygen. 300ml BOD bottles labeled appropriately were used in collecting water samples from different fish ponds at the different locations (29).

The total alkalinity was determined using the methyl orange method (29; 10). The pH was measured using a pH meter model British Milwaukee Smart Meter S204. Turbidity of the different water samples was taken *in-situ* using a Secchi disc. Temperature readings were taken using the mercury in bulb thermometer. The readings were taken *in-situ.* The procedures for collecting samples for BOD testing were as described for dissolved oxygen. For BOD measurement, two samples were taken at each site. One was tested immediately for dissolved oxygen and the second was incubated in the dark at $20 \pm 5^{o}C$ for 5 days and then tested for the amount of dissolved oxygen remaining. Conductivity was measured using conductivity meter of model American Phillips Hanna H19813-0.

Data were analyzed using SPSS statistical software version 18. Tools such as Analysis of Variance (ANOVA), Student's test and correlation co-efficient analysis and correlation matrixto test for significance, variation of the mean values and variables tested (18).

V. Results

In fish ponds A and B in Kuje Area Council, the length and breadth were 7.2m x 7.2 m, depth and volume of each pond was 4.8m and 248.83m^3. Fish pond A in Gwagwalada Area Council had length and breadth of 3.2m x 3.2m, the depth and volume were 4.5m and46.08m^{3}respectively, while fish pond B in Gwagwalada area Council, had length and breadth of 3.5m x 3.5m with depth and volume of 4.5m and 55.13m^3 respectively (25).

The mean values of these physico-chemical parameters were also determined for fish ponds in Gwagwalada in the dry season (November to January). Mean alkalinity values decreased steadily for fish pond A from November to December but increased slightly in January. The reverse was the case for fish pond B; it increased gradually from November to December and declined slightly in January (Table 1).

BOD values followed a pattern of gradual increase from November to December for fish ponds A and B and decreased slightly in January (Table 1).

Conductivity values for fish pond A decreased from November to January (Table 1), while that of fish pond B decreased from November to December and increased slightly in January.

Dissolved oxygen level for fish pond A increase from November to January (Table 1). For fish pond B, it rose gradually from November to January as well.

There was a sharp decrease in pH from November to December followed by a slight increase in January for fish ponds A and B with higher value recorded for pond B (Table 1).

Temperature values were steady for fish ponds A and B from November to December and followed by a decrease in January with lower value recorded for pond B (Table 1).

A gradual decrease in turbidity value was observed from November to December in fish pond A, followed by a slight increase in January (i.e a more turbid to a clearer water in January). On the contrary, turbidity value increased gradually from November to December in fish pond B followed by a decrease in January (i.e a clear to more turbid water) as seen in Table 1.

Similarly for ponds A and B (Kuje), the levels of physico-chemical parameters were observed as follows; for total alkalinity, there was a gradual increase from November to December with a sharp decline in January for fish pond A (Table 1), while for fish pond B, a sudden decrease was observed from November to December followed by an increase in January.

BOD level increased steadily from November to December and declined in January in fish ponds A and B with higher value recorded for pond B (Table 1).

Conductivity values increased geometrically from November to December in fish ponds A and B declined sharply in January with lower value recorded for pond A (Table 1).

Dissolved oxygen level decreased in December and rose slightly in January in fish pond A while it decreased in December for pond B and maintained a steady level from December to January (Table 1).

There was a sharp decline in pH in December followed by an increase in January for fish ponds A and B with higher value recorded for pond B (Table 1).

Temperature values rose from November to December and declined in January for both fish ponds (Table 1). A higher value was recorded for pond B.

Turbidity values steadily decreased from November to December, and increased subsequently in January in both ponds (i.e a more turbid to clear water as shown in Table 1 with higher value recorded in pond B.

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Table 1: Values of physicochemical parameters from November to January (dry season) in fish pond A and B (Gwagwalada Area Council) showing range and standard deviation

	Alkalinity (ppm)		BOD (mg/L)		Conductivity (µs/cm)		DO (mg/L)		pH		Temperature (°C)		Turbidity (Metres)	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
November	102-389	96-222	0.76-4.59	0.46-3.85	126-549	117-496	2.46-4.12	2.88-4.56	8.46-10.89	6.88-10.15	29-32	28-31	2.0-3.0	1.9-3.3
Mean/S.D	219±72.07	158.75±85.93	1.92±1.97	1.47±1.33	284.75±163.45	228.75±154.96	3.59±0.43	3.05±0.60	9.08±1.16	8.28±1.21	31.00±2.45	30±1.22	2.50±0.72	2.55±0.58
December	99-213	128-226	2.05-3.01	1.01-2.38	162-229	110-152	3.74-4.12	3.01-4.12	7.43-8.06	7.26-8.34	30-32	30-32	1.5-2.8	2.4-3.2
Mean/S.D	132.25±46.85	172±35.86	2.53±0.34	1.80±0.57	177.25±30.90	137.50±16.45	3.92±0.43	3.74±0.50	7.80±0.26	7.77±0.40	31.00±0.71	31.25±0.83	2.12±0.51	2.86±0.31
January	102-175	75-211	1.05-2.01	0.76-2.78	58-156	55-419	3.88-4.50	3.05-4.78	7.41-8.32	7.36-10.10	26-27	27-30	1.8-3.0	1.4-2.5
Mean/S.D	136.25±23.11	140±50.01	1.60±0.35	1.43±049	105.50±34.88	158.50±145.41	4.18±0.52	4.03±0.63	7.95±1.14	8.31±1.09	26.75±0.43	28±1.22	2.53±0.45	1.90±0.43

Fish Mortality:

A total of 850 (56.67%) fishes were recorded dead in fish pond A in Gwagwalada Area Council between November to January (Table 2). Fish mortality rate in fish pond B (Gwagwalada) was 955 (63.67%) between the same periods (Table 2).

For ponds A and B (Kuje), a strong positive correlation (r = 0.7 and 0.9; P < 0.05) respectively was observed between fish mortality rate and fluctuation in physico-chemical parameters from November to January (dry season). Strong positive correlation (r = 0.7 and 0.5; P < 0.05) respectively was also observed for ponds A and B (Gwagwalada) from November to January as well. There was a strong positive correlation (r=0.9, 0.9, 0.9 and 0.9) between pH, alkalinity, BOD and conductivity in fish ponds in Gwagwalada from November to January. All the physicochemical parameters were also strongly correlated in fish ponds in Kuje within the same period.

Table 2: Record of fish mortality in fish ponds A and B (Gwagwalada Area Council) between November and January.

	Total fish stock (ponds)	**No. dead (Pond A)**	**Percentage mortality (A)**	**Total fish stock (Pond B)**	**No. dead (Pond B)**	**Percentage Mortality (Pond B)**
November	1500	450	30.00%	1500	393	26.20%
December		250	16.67%		181	12.07%
January		150	10.00%		381	25.40%
Total		850	56.67%		955	63.67%

In Kuje Area Council fish pond A had 663 (44.20%) dead fishes between November and January (Table 3). fishes recorded dead in fish pond B between November and January were 728 {36.40%} (Table 3). There was no significant difference (p > 0.05) in the physicochemical parameters of these fish ponds in the dry season.

Table 3: Record of fish mortality in fish ponds A and B (Kuje Area Council) between November and January

	Total fish stock (ponds)	**No. dead (Pond A)**	**Percentage mortality (A)**	**Total fish stock (Pond B)**	**No. dead (Pond B)**	**Percentage Mortality (Pond B)**
November	2000	248	12.40%	1500	232	15.47%
December		318	15.90%		253	16.86%
January		162	8.10%		178	11.86%
Total		728	36.40%		663	44.20%

VI. Discussion

The physicochemical parameters of the ponds studied in Gwagwalada and Kuje Area Councils have shed some light into their productivity.

The mean temperature range was (25-31°C) in all ponds. This is still within the optimum temperature at which *Clariasgariepinus* which is the most common species cultured in these areas grow and reproduce. (2) and (17) reported that the best temperature range for optimum production of *Clarias* species is 25 - 31°C. This mean temperature values for the season could explain why *Clarias gariepinus* thrive so well, and remains the most common species cultured within these areas.

There was a drastic drop in the mean dissolved oxygen level below optimal levels to about 3.58 ± 0.68 mg/L to 4.26 ± 0.85mg/L with a temperature range of 26 to 31°C. This showed that increase in water temperature decreased dissolved oxygen level. The dissolved oxygen requirement for fish varies with species. Generally, the water quality for any fish cultured in tropical region must be such that the dissolved oxygen concentration must not be less than 3mg/L (22; 23). The mean dissolved oxygen contents of these fish ponds in Gwagwalada and Kuje showed that they are conducive for aquaculture in terms of the dissolved oxygen content. (7) and (14) noted that increased DO level is needed to support an increase in metabolic rates and reproduction.

(1); (8); (24) and (31) reported that water quality is commonly impacted by the introduction of organic matter. The mean BOD values was 1.26 ± 0.50mg/L to 2.79 ± 0.63mg/L, BOD value was high especially in November. Fallen leaves, and debris, and waste product of fishes and other insect population within the pond can cause possible increase in BOD. Eutrophication resulting from unused feed present in water is another possible reason for a sudden rise in BOD (8; 32). According to (8) increased BOD can threaten the survival of fish and other aquatic organisms. Occasional increase in BOD levels can be handled through regular monitoring of water quality (17; 31; 30; 20; 33).

The mean conductivity values for both fish ponds in the two areas was between 100 ± 16.23µs/cm to 320.50 ± 130.40µs/cm. Conductivity was significantly higher ($p < 0.05$). This high surface water conductivity (320.50 ± 130.40µs/cm) is a pointer to the pollution status of the pond caused by fallen leaves, debris, excessive nutrient from feeds, waste products of fishes and other insects population within the pond.

The total fish mortality was 3, 196 (49.2%) for the fish ponds in the two Area Councils. The strong positive correlation ($r = 0.5, 0.7, 0.9$ and 1.0 at $P < 0.05$) observed between fish mortality rates and fluctuation in some physicochemical parameters in ponds B Gwagwalada and Kuje suggests that high turbidity and low oxygen could be responsible for high fish kill. Low oxygen, high BOD, conductivity, pH as observed particularly in November and December could be responsible for high fish kills recorded in the dry season. According to (26) and (23) extreme levels of physico-chemical parameters such as BOD, Conductivity, DO, pH and Temperature could be lethal to fish. Weak positive correlation ($r=0.4$) observed between physicochemical parameters and fish mortality in pond B Gwagwalada suggest that other factors might have been responsible for the high fish mortality.

The pH range for the two fish ponds in Kuje (6.58-7.74) and Gwagwalada (9.02-9.41) during the dry season indicates alkalinity. This extreme alkaline pH in November and December coincided with period of high fish mortality in both ponds. This showed that the pH at those periods rendered the ponds unfavourable for the fishes. (13), USDA (32) and (23) indicated that the best water for fish cultivation is that which is neutral or slightly alkaline with a pH range of 7 to 8. (27) discovered that productive ponds, especially those with low alkalinity may have daytime pH of 10, which can be lethal to young fishes especially hybrid species. (23) also noted that fish can die from pH shock, a consequence of a sudden change in pH. According to Balarin and Hatton (5), environmental factors are about the closest one in determining the survival of fish, the effective utilization of nutrient and the general performance of cultured fish. Such factors included water quality parameters like temperature, dissolved oxygen, turbidity and pH (5).

Turbidity in ponds results from colloidal clay particles and colloidal organic matter originating from decay vegetation. Mean turbidity range of both fish ponds in the two areas was between 1.90 ± 0.43m to 4.45 ± 0.46m. According to (12) and (33), high levels of nutrient resulting from stocking densities and overfeeding can increase turbidity in aquaculture ponds. Turbidity restricts light penetration and limit photosynthesis (6).It is likely that the nutrient enrichment of ponds via organic matter such as faecal matter and unconsumed feed during the dry season assisted in increased production of algae thereby creating high turbidity values. The result is in line with previous works of (11) and (4).

The physicochemical parameters studied showed that the levels obtained are suitable for the cultivation of *Clarias gariepinus*, and hence for aquaculture. But pH values of these ponds tended towards high alkalinity, which may not be suitable for fingerlings and fry culture.

Continuous monitoring of these physicochemical parameters would give farmers firsthand information on strategies to employ in preventing and reducing fish kill. Furthermore it will help farmers, maintain good water quality in fish ponds pertinent to producing larger and healthier fishes for human consumption.

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References

[1] Abohweyere, P. O. (1990): Study of Limnological Parameters and Potential Fish Yield in Kigera Reservoir (Extensive System) in Kainji, New Bussa, Nigeria. Journal of Aquatic Sciences 5: 53 – 58.

[2] Adeniji, H. A and Ovie, S. I. (1982): Study and appraisal for the Water quality of the Asaoli and Niger Rivers. NIFFR Annual Report pp. 15-20.

[3] Annes, G. M. (1966). Modified Winkler method for Dissolved Oxygen Determination. Journal of Technology, 4(1): 32.

[4] Balarabe, M. (1998). Limnology and Zooplankton distribution of Makwaye River. M.Sc Thesis. Department of Biological Sciences, Ahmadu Bello University Zaria, Nigeria. pp 29.

[5] Balarin, J. D. and Hatton, J. P. (1979): Tilapia A Guide to their Biology and Culture in Africa. University of Stirling press Scotland, U. K.pp 174 -179

[6] Boyd, C. E. (1998). Water quality for pond aquaculture. Research and Development Series, 43: 1 – 11.

[7] Brian, O. (2006). Dissolved Oxygen Environmental quality. 84: 18766.

[8] Curtis, C. (1988). Oregon's water quality status assessment report. Environmental quality 305b: 117.

[9] Curtis, C. (1994). Oregon's water quality status Assessment report. Environmental quality 311b: 108 – 110.

[10] Environmental Review (2008). Coastal Zone Aquaculture Management. Aquaculture Strategic Plan, 5: 1 – 14.

[11] Forsberg, J. A., Dorsett, P. W. and Neill, W. H. (1996) Survival and Growth of Red Drum Scianeops ocellatus in Saline Ground Waters of West Texas, USA. Journal of the World Aquaculture. 27: 462 - 474

[12] Henderson, H. I. (1977). The Significance of Limnology in the Development of Fisheries in Man Made Lakes and River Basins. In the Proceedings of the International Conference of Kainji Lake and River Basins Development in Africa, Ibadan 11 – 17 December 1977 pp 14 – 16.

[13] Huet, M. (1972): Textbook of Fish culture Breeding and Cultivation of Fish Translated by H Kohn fishing News (Books) Ltd, Farnham, Survey England pp436.

[14] Ita, E. O. Balogun, J. K. and Adimula, A. B. (1995). A preliminary report of pre-impoundment of fishes Survey of Goronyo Reservoir Sokoto. NIFFR Annual Report. pp 35-38.

[15] Joseph, K. B., Richard, W. S. and Daniel, E. T (1993): An Introduction to Water Chemistry in Freshwater Aquaculture NRAC Fact Sheet 170: 23-25.

[16] Mabogunje, A. L. (1977). Report of the Ecological Survey of the Federal Capital Territory. Planning Studies Programme. The Environment. University of Ibadan, 2: 252 – 325.
[17] Madu, C.T. (1989). Hatchery Management of the Mudfish Clarias anguilaris(L). Ph.D Thesis. Department of Biological Sciences, Bayero University Kano, Nigeria. pp156.
[18] Mahajan, B.K. (1997). Methods in Biostatistics for Medical students and research Workers. 6th edition. Jaypee Medical Publishers Ltd. India. Pp 169-213.
[19] Meade, J. W. (1989). Aquaculture Management. Van Nostrand Reinhold Publishers New York. Pp 175.
[20] Mohammed, .A.H., Traifalgar, .R.F.M. and Serrano, A.E. Jr. (2013). Assessment of probiotic Application on Natural Food, Water Quality and growth performance of saline Tilapia Oreochromis mossambicus .L. cultured in concrete tanks. Fisheries and Aquaculture Journal 75:1-7.
[21] Piper, R. G., McElwim, I. B., Prme, L. E., McCranen, J. P., Flower, L. G. and Leonard, J. R. (1982). Fish hatchery management. Journal of Wildlife Management, 2: 6 – 10.
[22] Robert, K. (1979): The Range of Choice in Water Management. A Study of Dissolved Oxygen in Potomac Estuary. John Hopkins England. pp 48-56.
[23] Robert, C. S. (2007).Water quality consideration for Aquaculture. Journal of Animal Ecology, 2: 1 – 15.
[24] Saremi, .A., Saremi, .K., Saremi, .A., Sadeghi, .M. and Sadeghi, .H. (2012).The effect of aquaculture effluents on water quality parameters of Haraz River. Iranian Journal of Fisheries Sciences 12 (2):445-453.
[25] Solomon Wisdom G.O, Olatunde . A. A and Matur, B.M. (2013).Some Physicochemical Parameters of Selected Fish Ponds in Gwagwalada and Kuje Area Councils, Federal Capital Territory, Nigeria. Global Advanced Research Journal of Agricultural Science Vol. 2(1)330-336
[26] Stevens, C. (2007).Dissolved Oxygen. Science and Technology. 5: 1 – 5.
[27] Swann, L. (2007). A Fish Farmer's guide to Understanding Water Quality. Aquaculture Network 1b: 14 – 16.
[28] Taylor R., 2010, Fish Farming on Lake Kariba, Aquaculture 226: 101-112
[29] United States Environmental Protection Agency (2007). Monitoring Water quality I. The Volunteer, 53: 4 – 8.
[30] United States Environmental Protection Agency (2008). Water Quality Monitoring and Assessment Guidelines. The Volunteer, 54: 138 – 145.
[31] Utete, .B., Mutasa, .L., Ndhlovu' .N. and Tendaupenyu, .I.H. (2013) Impact of Aquaculture on Water Quality in Lake Kariba, Zimbabwe. International Journal of Aquaculture Vol.3, No.4 11-16 (doi: 10.5376/ija.2013. 03.0004)
[32] USDA U.S. Department of Agriculture, (1996). Aquaculture outlook. The Review. 4: 26 – 28.
[33] Walker, T. (1994).Pond Water quality management In A Farmer'sHandbook Turtle Press pty Ltd, Tas Australia pp.30-51.