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Influence of Chicken-Layer Manure and NPK 15-15-15 on Some Physico-Chemical Parameters of Borehole Waters

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Abstract

*The effect of two common fertilizers on physico-chemical parameters of water was assessed. Volume-converted recommended pond fertilization rates (RFR) of NPK and layer manure (LM) were serially diluted as RFR*0.3, RFR*0.7, RFR, RFR*1.5, and RFR*3, to yield solutions containing 8.4mgL^{-1}, 19.6mgL^{-1}, 28mg.L^{-1}, 42mgL^{-1}, and 84mgL^{-1} LM, and 4.5mgL^{-1}, 10mgL^{-1}, 15mgL^{-1}, 22.5mgL^{-1}, and 45mgL^{-1}, of NPK 15-15-15 in borehole water. A blank was used as control. The solutions were prepared in triplicate in plastic containers and placed indoors for 12 hours. Temperature (^{o}C), dissolved oxygen (mgL^{-1}), total hardness (mg$L^{-1}CaCO_3$), and pH were measured. There were significant differences in DO, pH, and total hardness levels in solutions of each fertilizer ($p<0.0001$), which remained within acceptable levels for fish culture in NPK but not in LM solutions. In comparison with control, DO levels in LM solutions decreased from 6.72±0.02mgL^{-1} to 4.12±0.02mgL^{-1} and1.53±0.02mgL^{-1} in treatments 3 and 5 respectively. Similarly, water hardness increased from 14mgL^{-1} $CaCO_3$ to 145mgL^{-1} $CaCO_3$and 346.7±5.8 mgL^{-1} $CaCO_3$, while pH decreased from 6.42±0.02to 5.86±0.02 and 5.68±0.03. Significant changes in physico-chemical parameters considered important for fish culture were seen in LM solutions, which should be weighed against its*

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Introduction

Fertilizersare used to increase pond natural food and consequently fish production. They provide an external source of nitrogen (N), phosphorus (P), and carbon (C) to boost primary and heterotrophic productivity (Woynarovich, 1975; Pruder, 1987; Schroeder, 1987). NPK and layer manure (LM) are two of the most commonly used fertilizers in pond aquaculture and terrestrial agriculture. NPK 15-15-15 contains the active ingredients supplied as urea, P_2O_5, and muriate of potash respectively, which make up 45% of its weight; as well as supposedly inert materials. LM averagely contains mineral and nutrient elements, and amino acids (Martins *et al.*, 1983; Gillick*et al.*, 2007) (Table 1).

Table1. Average composition of layer manure

Composition	% Dry matter)																			
Mineral			Ash	Al	Ca	Cl-	Fe	Mg	P	K	Na	As*	Cd*	Cr*	Cu*	Pb*	Mn*	Hg*	Se*	Zn*
27.6	0.11	8.07	0.87	0.54	0.5	2.29	2.24	0.6	1.5	0.94	4.9	66	4.6	320	<0.04	0.68	376			
Nutrient			Crude protein NPN x 6.25			Ether extract		Crude fibre		NFE	TDN	ADF	NDF	Lignin	Gross Energy (kcal·kg^{-1})			Dry Matter (%)		
			28		9.7	2.2		13		33.4	52.3	24.7	52.4	1.4	3047			84.7		
Amino acid		Argin	Cyst	Glyc	Hist	Leuc	Iso-L	Lysi	Meth	Pheny	Tyro	Vali	Alan	Prol	Glut	Seri	Threo	Aspa	Tryp	Total
	0.39	0.06	1.65	0.2	0.64	0.4	0.41	0.16	0.38	0.31	0.52	0.67	0.58	1.33	0.52	0.45	1.03	0.53	10.23	

Source: Martins *et al.* (1983). Argin-arginine, Cyst-cystine, Glyc-glycine,Hist-histidine, Leuc-leucine, Iso-L-iso-leucine, Lysi-lysine, Meth-methionine, Pheny-phenylalaline, Tyro-tyrosine, Vali-valine, Alan-alanine,Prol-proline,Glut-glutamine,Seri-serine,Threo-threonine,Aspa-aspartine,Tryp-tryptophan.. NPN-non-protein nitrogen, NFE-nitrogen free extract,TDN-total dissolved nitrogen, ADF-acid detergent (soluble) fibre, NDF-neutral detergent (insoluble) fibre.*Concentrations are given in ppm.

The fertilizers may therefore cause changes in the physico-chemical conditions of pond water, in addition to providing the nutrients needed to boost productivity. There is a dearth of information on the potential effect of these two commonly used fertilizers on water quality parameters.

Dissolved oxygen, pH, temperature, and water hardness, are important water quality parameters influencing pond productivity and fish welfare. This study assesses the effects ofrecommended doses of organic manure (chicken layer manure) and inorganic manure (NPK 15-15-15) on these parameters.

Materials and Method

The experiment was conducted in the laboratory of the Department of Fisheries and Aquatic Resources Management,Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

Preparation of Fertilizer Solutions

LM was obtained fresh, from the poultry unit of Michael Okpara University. The layer birds were raised in a battery cage system. They were fed on feed produced by Grand Cereals (Jos, Nigeria). The feed had the following composition: crude protein-16.5% minimum, fat-4% minimum, crude fibre-6.5% (maximum), calcium-3.6% minimum, available phosphorus-0.40% minimum, metabolizable energy-2650 kcal/kg minimum (manufacturer's data). The anticoccidialDiclazuril was administered as a 2.5% oral solution followed up with an antibiotic Bidox (1g in 40 litres water). Fresh LMwas oven-dried, at 60°C for 72 hours to determine moisture content. N, P, and K content were determined according to AOAC (1980). The recommended pond fertilization rate with chicken manurewas 224 $kg \cdot ha^{-1} week^{-1}$ (Ita, 1980).Kolo*et al.* (2003) recommended a "low" pond fertilization rate with NPK of $0.3 kg \cdot 25m^{-2} \cdot 2weeks$ and a "high" fertilization rate of $0.7 kg \cdot 25m^{-2} \cdot 2weeks$. These rates were volume-converted assuming a pond depth of 0.8m to give $28 mg \cdot l^{-1}$ for LM, and $15 mg \cdot l^{-1}$ for the lower limit of NPK 15-15-15. Using these rates as mid-point, serial dilutions of LM and NPK 15-15-15 were made. Weights of LM and NPK calculated as (recommended fertilization rate) RFR*0.3, RFR*0.7, RFR, aqueous solutions containing 8.4mg L^{-1}, 19.6mg L^{-1}, 28mg. L^{-1}, 42mg L^{-1}, and 84mg L^{-1} LM; and 4.5mg L^{-1}, 10.5mg L^{-1}, 15mg L^{-1}, 22.5mg L^{-1} and 45mg L^{-1}NPK 15-15-15 designated as treatments 1, 2, 3, 4, and 5 in the various fertilizers. The well water was used as control. The fertilizer concentrations and control were replicated thrice and were allowed to stand for 12 hours in plastic containers, at the end of which DO (mg L^{-1}), temperature (°C), pH, and total hardness (TH) (mg L^{-1} $CaCO_3$) were measured. DO and temperature were measured with HANNA® DO meter combined with thermometer. The pH values weremeasured with a pH meter. TH was measured with AQUASOL® TH test kit. The value of each physico-chemical parameter in each concentration was subtracted from the value in the control. This was done for each fertilizer.

Statistical Analyses

Statistical analysis was done with the aid of SAS (2002). Data on deviation of levels of physico-chemical parameters from control values were subjected to ANOVA. The level of each physico-chemical parameter of the borehole water as influenced by both fertilizers(NPK and LM) at various concentrations, were recorded and expressed graphically. Percentage data were first arc-sine transformed to improve normality (Gomez and Gomez,1984). In all such cases, transformed data were used for analyses while percentage data were reported.

Results

The stock LM contained 76%, 4.7%, 3.6%, and 2.1%, ofdry matter, N, P, and Krespectively. Results of the analysis of variance of deviation of physico-chemical parameters from control are given in Table 2. The levels of the physico-chemical parameters are given for the two fertilizers in Figs 1-3. Temperature was not significantly affected ($p>0.05$) but all other parameters were significantly affected ($p<0.0001$) by LM concentration. Both fertilizers caused significant changes in pH, DO, and TH of aqueous solutions ($p<0.0001$). LM and NPK concentrations inversely related with DO levels. LM also inversely related with pH levels. pH levels of solutions increased with increase in NPK solutions. TH increased with increase in LM

[1]from 6.72±0.02mg L^{-1}, to 4.12±0.02mg L^{-1} in treatment 3, and by 5.19±0.04mg L^{-1} to 1.53±0.02mg L^{-1}in treatment 5. The DO levels measured represent respectively 90%, 64%, 51%, 51%, 38%, and 26% saturation in control, treatments 1, 2, 3, 4, and 5. TH increased by 131 mg L^{-1} $CaCO_3$to 145 mg L^{-1} $CaCO_3$ in treatment 3. pH decreased by 0.56±0.03 units to 5.86±0.02.

Discussion

DO and TH levels of>5mg L^{-1}, and 50-150mg $L^{-1}$$CaCO_3$ respectively, are considered optimal for fish culture, whereas 2-5mg L^{-1} and 20-300mg L^{-1} $CaCO_3$ are the tolerance range while optimal pH level is from 6.7-8.6, and <6.7 and >8.6 injurious to fish (Ovie and Adeniji, 1990; Bhatnagar and Devi, 2013). LM had a pronounced effect while NPK 15-15-15 had a relatively mild effect on the physico-chemical parameters of water. DO is widely

Table 2: Effect of NPK 15-15-15 and layer manure on some selected water quality parameters

Fertilizer concentration (multiples of recommended fertilization rate-RFR)							ANOVA
Treatment		1	2	3	4	5	
Physico-chemical parameter							
Dissolved oxygen	NPK	-0.49±0.02^{d}	-0.56±0.05^{c}	-0.64±0.06^{b}	-1.13±0.03^{a}	-1.22±0.09^{a}	****
	LM	-1.62±0.12^{a}	-2.07±0.04^{b}	-2.60±0.02^{c}	-3.28±0.06^{d}	-5.19±0.04^{e}	****
Total hardness	NPK	12^{d}	18^{d}	23.3±1.2^{c}	28.3±2.5^{b}	54.3±5.8^{a}	****
	Layer manure	16.3±0.58^{e}	20.3±1.2^{d}	131^{c}	182.67±5.67^{b}	332.67±5.67^{a}	****
pH	NPK	0.29±.19^{d}	0.55±0.07^{c}	1.27±0.08^{b}	1.35±0.06^{b}	1.66±0.08^{a}	****
	Layer manure	-0.32±0.26^{a}	-0.38±0.06b^{a}	-0.56±0.03^{bc}	-0.62±0.11^{c}	-0.74±0.01^{c}	****
Temperature	NPK	-0.30±0.1^{b}	-0.03±0.21^{a}	-0.07±0.06^{a}	0^{a}	0.07±0.06^{a}	**
	Layer manure	0.03±0.06^{a}	-0.10±0.1^{b}	-0.10±0.1^{b}	-0.07±0.06^{ba}	0	NS

Temperature (°C), dissolved oxygen ($mg L^{-1}$), total hardness ($mg L^{-1}$ $CaCO_3$), and pH levels of aqueous solutions containing 4.5$mg L^{-1}$, 10.5$mg L^{-1}$, 15$mg L^{-1}$, 22.5$mg L^{-1}$, and 45$mg L^{-1}$ 15-15-15(treatments 1, 2, 3, 4, and 5 respectively); and 8.4$mg L^{-1}$, 19.6$mg L^{-1}$, 28mg L-1, 42mg L-1, and 84$mg L^{-1}$ of layer manure (treatments 1, 2, 3, 4, and 5 respectively). Values are means of three replicates. Means (±SD) in the same row with different superscript letters are significantly different ($p<0.05$) (Fisher's LSD). *-$p<0.05$, **-$p<0.01$, ***-$p<0.001$, ****-$p<0.0001$.NS-not significant ($p>0.05$).

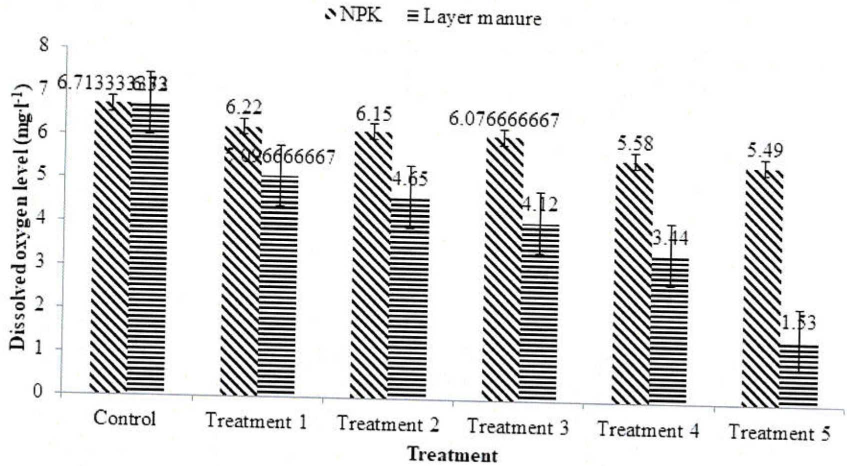

Fig. 1: Dissolved oxygen ($mg L^{-1}$) levels in aqueous solutions containing $4.5mg L^{-1}$, $10.5mg L^{-1}$, $15mg L^{-1}$, $22.5mg L^{-1}$, and $45mg L^{-1}$ 15-15-15(treatments 1, 2, 3, 4, and 5 respectively); and $8.4mg L^{-1}$, $19.6mg L^{-1}$, 28mg L-1, 42mg L-1, and $84mg L^{-1}$ of layer manure (treatments 1, 2, 3, 4, and 5 respectively).

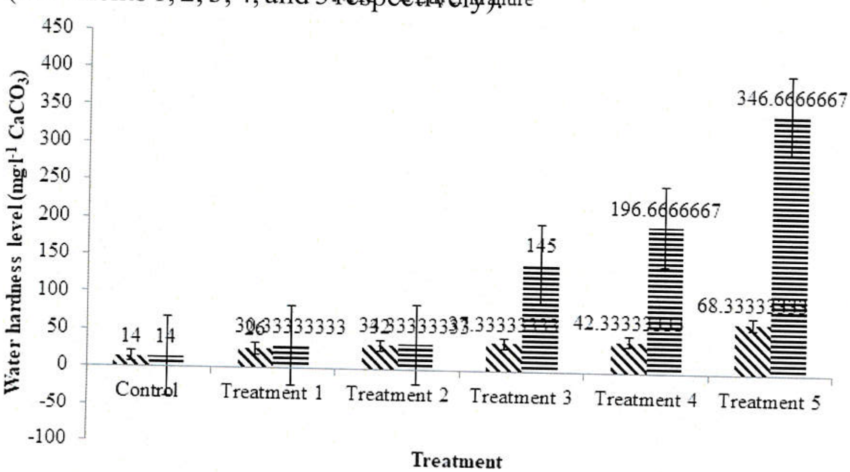

Fig. 2: Total hardness of aqueous solutions containing 4.5mgL^{-1}, 10.5mgL^{-1}, 15mgL^{-1}, 22.5mgL^{-1}, and 45mgL^{-1} 15-15-15(treatments 1, 2, 3, 4, and 5 respectively); and 8.4mgL^{-1}, 19.6mgL^{-1}, 28mgL-1, 42mgL-1, and 84mgL^{-1} of layer manure (treatments 1, 2, 3, 4, and 5 respectively).

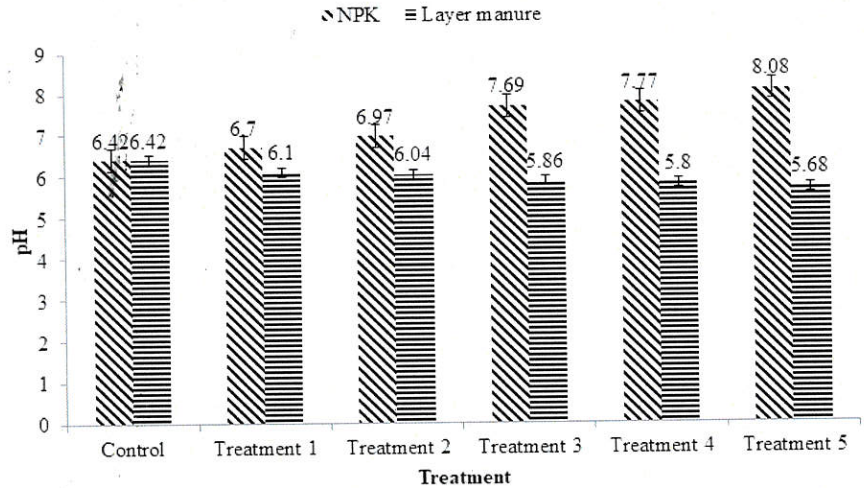

Fig. 3: pH of aqueous solutions containing 4.5mgL^{-1}, 10.5mgL^{-1}, 15mgL^{-1}, 22.5mgL^{-1}, and 45mgL^{-1} 15-15-15(treatments 1, 2, 3, 4, and 5 respectively); and 8.4mgL^{-1}, 19.6mgL^{-1}, 28mgL-1, 42mgL-1, and 84mgL^{-1} of layer manure (treatments 1, 2, 3, 4, and 5 respectively).

Acknowledged as the single most important chemical factor affecting fish (Ovie and Adeniji, 1990; Boyd and Tucker, 1992). DO decreased but remained within optimal limits for fish culture in NPK solutions. DO levels were significantly affected by LM concentration.

Under the prevailing temperatures in the various LMtreatments, the DO concentration and saturation in the LM treatments is considered to be at optimal tolerance, sub-lethal, and lethal range in control; treatments 1, 2, 3, 4; and treatment 5 respectively. Severe oxygen depletion in surface water has been reported to result from very high manure loadings (USEPA, 2013).

pH affects important physico-chemical parameters like water column

P (Shrestha and Lin, 1996) and un-ionized ammonia hence ammonia toxicity. In NPK solutions, pH increased but remained within optimal limits for fish culture. In LM solutions on the other hand, pH decreased, probably due to the uric acid content of the manure, to levels injurious to fisheven in the fertilizer concentration recommended for pond fertilization.

The American Society of Engineers and WHO (2011) classifiedwater as soft (TH 0-60mg L^{-1} $CaCO_3$), moderately hard (TH 61-120mg L^{-1} $CaCO_3$), hard (TH 121-180mg L^{-1} $CaCO_3$), and very hard (180 mg L^{-1} $CaCO_3$). TH increased but fellwithin optimal limits for fish in NPK solutions, but increased from soft in control to very hard in LM treatment 5. Hardness levels injurious to fish culture were observed in LM treatments 4 and 5. Carbonate is responsible for the buffering capacity of hard water because the carbonatebinds the acids.The relative deficiency of calcium in LM may have reduced this capability in LM solutions, resulting in net increase in acidity of the manure solutions.

Abdel-Tawwab*et al.* (2002) reported that low doses of NPK (maximum dose corresponding to treatment 1 in this study), had no significant effect on pH, DO, temperature and TH. The benefits of the use of LM in view of its organic matter enrichment should be weighed against its drastic effects on water quality parameters. It has been shown in this study that significant water quality deterioration occurs even at moderate manure loadings, including the rates recommended for pond fertilization. It is suggested that fertilization with LM be done simultaneously with limingand at periods of peak oxygen and pH levels in ponds. Otherwise, recommended rate of application of lime should be specific to fertilizer, soil, and water pH; as opposed to water and soil pH combinations. LM application has shown a dose-response relationship with water quality which deterioratesto levels injurious to fish at doses equal to treatment 3. The fertilizer should therefore be applied in ponds at maximum rates corresponding to treatment 2 (42kg ha^{-1} $week^{-1}$).

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