

Dynamics of Dissolved Oxygen in Relation to pH and Survival of Fish Culture in Fiber Glass Tank

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Abstract— The study aims at determining the dynamics of dissolved oxygen in relation to pH and survival of fish culture in fibre glass tank. Three feeds were used. They are dried chicken manure only (Treatment I), mixture of dried chicken manure with commercial diet (coppens) (Treatment II) and commercial diet only (coppens only) (Treatment III). The physicochemical characteristics of water for the treatments (T_I , T_{II} and T_{III}) in fibre glass tank were determined twice a month using standard methods. ANOVA was used to analyze the effects of the rate of changes between dissolved oxygen, pH and the fish survival.

The result from this study showed that the fish in treatment III had the highest weight gain of 272.10g followed by treatment II (172.07g) and 3 (143.47g) ($P < 0.05$). There was no significance difference at probability level 0f ($P < 0.05$) in survival rate. Variation exists in the water quality parameters examined, dissolved oxygen and pH falls within the range for fish survival. pH was correlated with dissolved oxygen. The findings also provide the useful information about the conditions of the three treatment which will ultimately help to manage the water body for sustainable production. The model showed that dissolved oxygen depends on pH.

Keywords— Dissolved Oxygen, dried chicken, commercial diet, Fiber Glass Tank.

I. INTRODUCTION

Water quality is the totality of physical, biological and chemical parameters that affect the growth and welfare of cultured organisms. Water quality affects the general condition of cultured organism as it determines the health and growth conditions of cultured organism.

Water quality parameters vary with feeding frequency and have wider impacts on primary productivity and fish production. Good water quality refers to that with adequate oxygen, proper temperature, transparency, limited levels of metabolites, and optimum levels of other environmental factors affecting fish culture.

Water quality in tanks change continuously and are affected by each other along with the physical and biological characteristics.

The term pH refers to the hydrogen ion (H^+) concentration in water, pH refers to how acidic or basic a water is. pH is interdependent with a number of other water quality constituents, including carbon dioxide, alkalinity and hardness. It is known to influence the toxicity of hydrogen sulphide, cyanides and heavy metals, as well as having an indirect effect on ammonia levels; un-ionized NH_3 increases with pH (Klontz 1993).

Meade (1989) recommended that pH be maintained at between 6.5 and 8 for all aquaculture species. In fresh water, pH can change quickly due to the amount of carbon dioxide added or removed during plant growth.

Most estuarine and freshwater species are tolerant of a relatively wide range of environmental pH (Tomasso 1993). Swingle (1969) claims that the desirable range for warm-water pond fish is 6.5 to 9. A range of 5 to 9 was

considered safe by the European Inland Fisheries Advisory Commission (EIFAC 1969). ANZECC and ARMCANZ (2000) and (Begum et al, 2014) recommended guide lines for pH maintained between 5.5 and 9.0 for fresh water.

It should be noted that pH can change by the hour as a function of photosynthesis which removes carbon dioxide.

Dissolved oxygen (DO) is considered as one of the most important water quality parameters in aquaculture. It is needed by fish to respire and perform metabolic activities. Thus, low levels of dissolved oxygen in fish culture cause stress to cultivated fish (Boyd, 1982) resulting in reduced feed intake, poor feed conversion and growth, and are often linked to fish kill incidents.

Dissolved oxygen refers to the level of free, non-compound oxygen present in water or other liquids. It is an important parameter in assessing water quality because of its influence on the organisms living within a body of water (Wetzel, 2001). A dissolved oxygen level that is too high or too low can harm aquatic life and affect water quality (Kemker, 2013). UNEP (2007) pointed out that dissolved oxygen level was a good indicator for water pollution.

Dissolved oxygen is also produced as by product of photosynthesis from phytoplankton, algae, seaweed and other aquatic plants (Kemker, . 2013).

Dissolved oxygen and pH affects directly or indirectly other limnological parameters such as transparency, viscosity, total dissolved solids and conductivity (Whitney, 1942); all of which constitute the very important physical and chemical parameters that form the basis for an enlightened fisheries and water resources management (Araoye et al., 2007).

DO is measured by the azide modification of the Winkler method. The DO level in natural and wastewater depends on the physical, chemical and biochemical activities in the water bodies. Oxygen is considered as poorly soluble in water. Its solubility is related to pressure and temperature. In fresh water, DO reaches 14.6mg/l at 0°C and approximately 9.1, 8.3 and 7.0mg/l at 20, 25 and 35°C, the level of saturated DO is 9.0 – 7.0mg/l. for living organism, about 4mg/l of minimum DO should be in water.

Initial weight of Fish in gram (g):

Final weight of fish harvested (g)

$$Bi-weekly mean weight gain(g) = \frac{Total bi-weekly weight(g)}{Total No of fish weight(g)} \quad (1)$$

$$Absolute growth rate (g/day) = \frac{Final weight - Initial weight of fish}{Culture period(days)} \quad (2)$$

Dissolved oxygen is critical for fish and other water inhabitants. Generally, waters with dissolved oxygen concentrations of 5.0 milligrams per liter (mg/L) (equivalent to 5 parts per million (ppm)) or higher can support a well balanced, healthy biological community. As dissolved oxygen drops below 5.0 mg/L, aquatic life is put under stress. (Hach Company 2001).

II. MATERIALS AND METHODS

The study was conducted at the Nigerian Institute for Oceanography and Marine Research Sapele out station Sapele Local Government Area of Delta State, Nigeria (N50 54'5''E005°39'56.4'). six circular fibre glass tanks were used in the experiment. All experimental tanks were identical in shape and size. Tanks capacities were 3.08m³ and depth of 60.5cm each and diameter 176.78cm. Sex reversed Nile tilapia (*Oreochromis niloticus*) of 0.80g average size was stocked.

The tanks were divided into three culture systems that is intensive, semi intensive culture and extensive culture in triplicates for each culture system. The treatments were dried chicken manure only, dried chicken manure plus commercial diet (coppens) and commercial diet (coppens) only These treatments was used to determine the dissolved oxygen dynamics in each culture system and to predict the effect of pH and survival of fish culture in fibre glass tank. Three hundred (300) fish were stocked in each tank.

The fish used for this experiment were fingerlings of all male Nile tilapia (*O. niloticus*). Fish were fed at 800hr and 1600hr with dried chicken manure, chicken manure plus commercial feed (coppens) and commercial feed (coppens) only. The feeding rate was 5% of the total fish biomass presented in each tank and the feed amount was adjusted every two weeks for each tank separately according to the biomass available which was determined during sampling. Random samples of 75 fish were taken biweekly from each treated tank during the experimental period. Fish samples were obtained in the early morning (between 7.00hr to 9.00hr)

From the measurements, the following parameters were determined:

$$\text{Specific growth rate (SGR\% day)} = 100 \times \frac{(\ln \text{ Final body weight} - \ln \text{ Initial body weight})}{\text{Rearing period in days (t)}} \quad (3)$$

where

ln = natural log

$$\text{Feed Conversion Ratio} = \frac{\text{Total weight of feed consumed}}{\text{Total weight of fish produced}} \quad (4)$$

$$\text{Fish Survival Rate (SR\%)} = \frac{\text{Total fish number harvested}}{\text{Total fish number stocked}} \times 100 \quad (5)$$

$$\text{Fish Yield} = \frac{\text{Total weight of fish harvested over culture}}{(g / 180 \text{ days} / 3.08 m^3)} \times 100 \quad (6)$$

The water quality was monitored using the following water testing meters: At the end of the hand picking. Total weight of the fish was taken Random fish samples 50 from each treatment were taken to determine the final mean weight. Harvested fish were kept in plastic containers for marketing.

From the foregoing the primary data collected where used for modeling the dissolved oxygen in the fibre

glass tanks with respect to the treatments administered to them vis-à-vis Chicken manure, Chicken manure plus coppens and Coppens only . The average (mean) for each parameter per two weeks was computed, considering the values from three treatments. their interrelations of twenty four weeks were determined by the analysis of variance (ANOVA) using the MiniTab 17 software. All test were carried out at 5% probability level ($P < 0.05$).

III. RESULT AND DISCUSSION

Treatment I

Table 1: Water quality parameter in time-weeks for Treatment I

Bi Weekly	pH	Yield	Dissolved oxygen
2	6.77	0.83	3.577
4	9.246	1.07	12.797
6	9.826	4.5	14.642
8	10.206	9.14	16.425
10	10.088	14.05	16.736
12	9.47	19.74	17.094
14	8.704	26.57	15.842
16	8.924	40.38	16.603
18	8.598	59.38	16.875
20	8.577	79.27	17.222
22	8.463	111.48	17.211
24	8.314	143.47	16.481
Total	107.186	509.88	

Table 2: Water quality parameter in time-weeks for Treatment II

Bi-Weekly	pH	Yield	Dissolved oxygen
2	6.77	0.77	4.581
4	8.563	1.39	8.058
6	8.66	6.63	10.521
8	9.202	13.64	12.978
10	9.149	20.55	14.114
12	8.326	27.84	11.718
14	8.135	35.79	11.397
16	7.847	58.04	10.792
18	7.809	85.04	10.561
20	7.743	107.67	10.567
22	7.651	139.87	10.461
24	7.611	171.97	10.706
Total	97.466	669.2	

Table 3: Water quality parameter in time-weeks for Treatment III

Bi-Weekly	pH	Yield	Dissolved oxygen
2	6.77	0.8	3.767
4	9.163	1.98	10.525
6	8.921	15.53	9.662
8	8.831	33.17	9.733
10	8.065	51.57	10.7
12	7.8	72.09	7.625
14	8.009	103.81	9.439
16	8.237	135.35	10.125
18	8.316	174.63	10.461
20	8.109	206.73	10.339
22	7.981	239.1	10.428
24	7.904	272.1	10.45
Total	98.106	1306.86	

The model intended to be developed is of the form

$$Y = b_0 + b_1y_1 + b_2y_2 \quad (1)$$

The Table below show the result of the experimental Do and model DO
For Treatment I

Table 4: Percentage error of Model and Experimental DO for Treatment I

WEEK	DOM	DO _E	%error
2	3.644	3.577	-0.0187
4	14.5444	12.797	-0.1365
6	15.1345	14.642	-0.0342
8	16.997	16.425	-0.0348
10	18.3992	16.736	-0.0994
12	18.7659	17.094	-0.0978
14	19.9305	15.842	-0.2581
16	17.8626	16.603	-0.0759
18	18.4584	16.875	-0.0938
20	18.6662	17.222	-0.0839
22	18.7688	17.211	-0.0905
24	19.3276	16.481	-0.1727

For Treatment II

Table 5: Percentage error of Model and Experimental DO for Treatment II

WEEK	DOM	DO _E	%error
2	4.58089	4.581	0.00002
4	9.11581	8.058	-0.1313
6	9.86828	10.521	0.0620
8	12.4121	12.978	0.0436
10	14.3228	14.114	-0.0147
12	11.674	11.718	0.0038
14	11.521	11.397	-0.0109
16	10.585	10.792	0.0192
18	10.5961	10.561	-0.0033
20	10.4627	10.567	0.0099
22	10.6665	10.461	-0.0199
24	10.6623	10.706	0.0041

For Treatment II

Table 6: Percentage error of Model and Experimental DO for Treatment III

WEEK	DO _M	DO _E	%error
2	3.80452	3.767	-0.01
4	10.5692	10.525	-0.0042
6	9.25225	9.662	0.0424
8	10.2043	9.733	-0.0484
10	10.1484	10.7	0.0516
12	8.05753	7.625	-0.0567
14	9.09966	9.439	0.0359

16	10.6125	10.125	-0.0481
18	10.2605	10.461	0.0192
20	10.7015	10.339	-0.0351
22	10.2144	10.428	0.0205
24	10.3366	10.45	0.0109

Table 7: ANOVA results for Treatment I

Source	Sum of Squares	Degree of freedom	Mean square	F value	P value
Model	159.770	7	22.8243	24.34	0.004
x ₁	14.449	1	14.4491	15.41	0.017
x ₂	22.032	1	22.0321	23.50	0.008
Error	3.750	4	0.9376		
Total	163.520	11			

Table 8: ANOVA results for Treatment II

Source	Sum of Squares	Degree of freedom	Mean square	F value	P value
Model	60.6163	7	8.65947	17.39	0.008
x ₁	6.4582	1	6.45815	12.97	0.023
x ₂	0.1662	1	0.16622	0.33	0.594
Error	1.9919	4	0.49798		
Total	62.6082	11			

Table 9: ANOVA results for Treatment III

Source	Sum of Squares	Degree of freedom	Mean square	F value	P value
Model	41.2256	7	5.8894	16.05	0.009
X1	0.3885	1	0.3885	1.06	0.362
X7	7.7167	1	7.7167	21.03	0.010
Error	1.4676	4	0.3669		
Total	42.6932	11			

The results presented in Tables 7, 8 and 9 shows that for the models representing all three treatments, the model p-value was less than 0.05. This suggests that the response models were significant and can be used for predictive purpose.

Table 10: Coefficient estimate for model representing Treatment I

Source	Coefficient estimate	Standard error Coefficient	T value	VIF
Const	101.9	26.5	-3.84	-
X1	5.65	1.44	3.93	21.47
X7	0.04841	0.00999	4.85	2.57

Table 11: Coefficient estimate for model representing Treatment II

Source	Coefficient estimate	Standard error Coefficient	T value	VIF
Constant	25.1	31.6	-0.79	-
x ₁	4.42	1.23	3.60	16.28
x ₇	0.010	0.0173	0.58	21.95

Table 12: Coefficient estimate for model representing Treatment III

Source	Coefficient estimate	Standard error Coefficient	T value	VIF
Const	-67.4	17.8	-3.78	
x ₁	-2.09	2.02	-1.03	47.91
x ₇	0.0241	0.00525	4.59	7.55

The variance inflation factor in all the three treatments are very large since multicollinearity exist among the variables. The coefficient estimate show that there is positive effect on the model and the response for both Treatment I and Treatment II while Treatment III show both positive and negative values. The positive value indicate positive effect on the model while the negative value indicate antagonistic effect on the response.

Growth Performance Mean Weight Gain (MWG)

Using eq. .1, the mean weight gain in treatment I was found to be 42.49 while that of treatment II recorded was 55.77 and treatment III was 108.91. Fish in treatment III showed the highest mean weight gain of 108.91 which was significantly different from all the other treatments (Table 4.11). Fish in treatment I and II recorded 42.49 and 55.77 respectively, which were not significantly different from each other.

Table 13: Bi Weekly Mean Weight Gain of All Male

Tilapia for the three Treatment tanks for 24 weeks of culture

Weeks	Chicken Manure Only (g)	Chicken Manure With Coppens (g)	Coppens Only (g)
2	0.83	0.77	0.80
4	1.07	1.39	1.98
6	4.50	6.63	15.53
8	9.14	13.64	33.17
10	14.05	20.55	51.57
12	19.74	27.84	72.09
14	26.57	35.79	103.81
16	40.38	58.04	135.35
18	59.38	85.04	174.63
20	79.27	107.67	206.73
22	111.48	139.87	239.10
24	143.47	172.97	272.10
X	42.49b	55.77b	108.9a

Growth Performance

Survival Rate

Treatment III fed with coppens only perform better in terms of growth performance while Treatment I has the

lowest performance. Survival rate exceeded 90% in all treatments. Treatment I recorded 77%; treatment II 99% and treatment III 99.33% which is the highest survival rate. Table 14 gives the values and this was estimated using eq. 5.

Table 14: Growth performance of all male Tilapia fed with chicken manure only, chicken manure with coppens and coppens only in a fibre glass tank.

Parameters	Treatments		
	I (Chicken manure only)	II (Chicken manure with coppens)	III (Coppens only)
Initial mean weight (g)	0.83	0.77	0.80
Mean weight gain (g)	42.49b	55.77b	108.91a
Final mean weight (g)	143.47c	171.97b	272.10a
Specific growth rate (%/day)	4.96a	5.14a	5.60a
Survival rate (%)	77a	99a	99.33a
Feed intake (g feed/fish)	584.50c	823.70b	1596.30a
Feed Conversion Ratio	1.95	2.75	5.32

Mean with different superscripts in the same row are significantly different

Water quality analysis

Table 15: Water quality parameters during the experimental period

Parameters	Treatments		
	Chicken manure only	Chicken manure + coppens	Coppens only
Dissolved Oxygen	15.164	10.539	9.417
pH	8.860	8.073	8.108
Temperature °C	28.517	28.191	29.044
Electrical Conductivity	293.10	314.30	313.40
Unionized ammonia (NH ₃)	0.50	12.80	0.20
Total Dissolved Solid	147.09	157.19	156.55
Transparency (cm)	32.50	25.20	16.42

IV. CONCLUSION

The water quality parameter table show suitable environmental conditions for rearing All Male Tilapia during the experimental period.

It was observed that dissolved oxygen interact with pH, the yield increase as the dissolved oxygen

increase, also the lower the pH the better the dissolved oxygen for the survival of the fish.

It was observed that the response model is significant ($p < 0.05$).

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