PJN
ISSN 1680-5194

Pakistan Journal of Nutrition

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 8 (9): 1373-1379, 2009
ISSN 1680-5194

Organic Enrichment of Fish Ponds: Application of Pig Dung vs. Tilapia Yield

R.L. Bwala[1] and E. Omoregie[2]
[1]National Institute for Freshwater Fisheries Research, PMB 6006, New Bussa, Nigeria
[2]Department of Fisheries and Aquatic Sciences, University of Namibia,
Private Bag 13301, Windhoek, Namibia

Abstract: An experiment was conducted to evaluate the effects of different levels of pig dung pond fertilization to test tilapia yield at each level of concentrations. The concentrations used were 8.36, 20.89 and 33.43 g/m^3/day; for Low Concentration of Pig Dung (LCPD), Medium Concentration of Pig Dung (MCPD) and High Concentration of Pig Dung (HCPD) respectively. Fish in the treated ponds received no supplementary feeding throughout the experimental period. In this study, the effect of pig manure on water quality, the survival and growth of *Oreochromis niloticus*, the carcass composition of the fish were investigated. Growth indices were low in LCPD and they increased successively in MCPD and HCPD; however, they compared favourably well with those recorded in the control ponds in which the fish were fed. Survival was highest (96%) in HCPD and control ponds while the lowest (86%) was recorded in the LCPD experimental. There was no significant difference ($p>0.05$) in fish carcass composition at the end of the experiment. Water quality parameters monitored during the experimental period were all within favourable range for aquaculture production; with daytime mean values of dissolved oxygen being 7.84±0.38, 8.92±0.44 and 7.77±0.56 mg/l in LCPD, MCPD and HCPD experimental ponds respectively. Also, HCPD experimental ponds yielded better growth indices and compared favourably with results obtained in the control experimental ponds.

Key words: Fertilizer, survival, growth, carcass quality, plankton

INTRODUCTION

For centuries fish farmers have increased fish yields by fertilizing their fishponds using inorganic fertilizers. However, due to rising cost of inorganic fertilizers, most especially in developing countries as reported by Swift (1993), greater attention is being focused on the use of organic fertilizers; such as animal waste as documented by Das *et al.* (2005). The use of manure in aquaculture was reported by Wohlfarth and Hulata (1987) to supports the production of protein using inputs of little nutrient value to man or livestock. Animal manures have a long history of use as a source of soluble phosphorus, nitrogen and carbon for algal growth and natural food production (Knud-Hansen, 1998), hence resulting in higher fish yield. However, yield varies greatly amongst the different types of animal manure and fish being cultured as well as the application rate.

The use of animal manure in integrated systems remains poorly developed in many parts of Africa, as opposed to South East Asia where it is well developed (Pullin and Prein, 1995). This is due to the fact that aquaculture technology as reported by Kang'ombe *et al.* (2006) is under-utilized and the effect of organic manure on production of fish in aquaculture remains unexplored in Africa. Inadequate pond inputs, both quality and quantity, has been identified as one of the key factors limiting production in small-scale aquaculture.

Animal manure is often used in semi-intensive systems to improve the primary production of the ponds and fish growth (Nguenga *et al.* 1997; Boyd and Tucker, 1998 and Das *et al.*, 2005). Poultry and cattle manures have been tried with *Oreochromis niloticus* and *O. shiranus* in ponds and produced good results (Gupta *et al.*, 1992, Knud-Hansen *et al.*, 1993; Kamanga and Kaunda, 1998). Hepher and Pruginin (1982) and Boyd and Tucker (1998) noted that pig manure has been tried in aquaculture in many areas with promising results, however no similar reports are available on the yield of the Nile tilapia, *Oreochromis niloticus* culture in Africa.

The aim of this study was to determine the effect of different levels of pig dung on the growth and survival of the Nile tilapia *Oreochromis niloticus* under typical tropical conditions.

MATERIALS AND METHODS

Experimental facilities and set up: This experiment was carried out in outdoor concrete ponds at the Hydrobiology and Fisheries Research Unit, a facility of the Department of Zoology, University of Jos, Nigeria. Twelve concrete ponds measuring 1.17 m^2 and 0.7 m deep were used. A constant water depth of 0.35 m was maintained throughout the period of the experiment. This was achieved by constantly adding water to the tanks anytime a shortage was observed. Four treatments; Low Concentration of Pig Dung (LCPD), Medium Concentration of Pig Dung (MCPD), High Concentration of Pig Dung (HCPD) and no-manure as a control, were assigned to ponds at random in a Completely

Randomized Design (CRD) and each was replicated three times.

Throughout the period of the experiment, fish in the control ponds were fed exclusively with formulated fish diet (Table 1) at 4% of their body twice weight daily (08h.00 and 14h.00). No supplementary feeding was given to the fish in the ponds fertilized with the pig dung. The pig dung was collected in its dried form from the piggery at Federal College of Forestry, Jos, Nigeria.

Fertilization regime: Two weeks before the commencement of the experiment, thin layer of soil was spread on the bottom of each of the treatment tanks followed by a basal application of the manure at a quantity of 351 g per pond, following recommendation by Okoye (1996), the tanks were then flooded with water to the required capacity. Equal quantity of the initial basal application of manure was reapplied a week later through surface broadcast. This was done so as to aid blooming and to ensure fish are not starved at the point of stocking. From the day of stocking the manure was subsequently applied daily as suggested by Yun *et al.* (1987); at application rate of 8.36, 20.89 and 33.43 g/m^3/day for low, medium and high concentrations respectively. The moisture, nitrogen, phosphorous and organic carbon contents of the pig dung used are presented in Table 2.

Table 1: Raw ingredients and proximate composition of formulated diet fed to fish in the control ponds

Ingredient	Composition (%)
Fishmeal	35
Groundnut cake	30
Maize flour	20
Cassava flour	5
Corn oil (Solitaire®)*	5
Vitalyte**	5
	100
Nutrient	Composition (%DM)
Crude protein	40.84
Moisture content	7.20
Ash content	5.87
Ether extract	24.30
Crude fibre	3.73
Nitrogen free extracts	18.06
	100.00*

100% pure refined corn oil, **specification per 1000g: Vitamin A 15,000.000iu, vitamin D3 4,400,000iu, vitamin E 1,350iu, vitamin K 4,350 mg, vitamin B2 4,350 mg, vitamin B6 2,350 mg, vitamin B12 11,350 mg, vitamin C 1000 mg, Nicotinic Acid 16,700 mg, Pantothenic acid 5,350 mg, Potassium chloride 87,000 mg, Sodium sulphate 212,000 mg, Sodium chloride 50,000 mg, Magnesium sulphate 12,000 mg, copper sulphate 12,000 mg, Zinc sulphate 12,000 mg, Methionine 10,000 mg

Table 2: Manurial value of the pig dung used for this investigation

	Composition (%)
Moisture	70.05
Total Nitrogen*	0.84
Phosphorus (P_2O_5)*	0.51
Organic carbon*	59.06

*On dry weight basis

Biochemical analysis of formulated fish diet, pig dung and fish: The pig dung applied to the experimental ponds were analyzed for proximate analysis before application to the treatment ponds using standard methods (AOAC, 1990). Similarly, the formulated fish diet fed to fish in control ponds and fish carcass composition were also analyzed for proximate analysis. All biochemical analyses were done on dry matter basis by drying pre-weighed samples in a laboratory oven at 105^{o}C for about 24 h to reach a constant weight.

Fish stocking and sampling: Juvenile Nile tilapia, *Oreochromis* niloticus of mixed sex were collected from Panyam Fish Farm, Panyam, Nigeria. They were kept in a large tank for a 1-week acclimation period to make sure that the fish were healthy before stocking. During this time, the fish were fed formulated fish diet at 4% body weight twice daily (08h.00 and 14h.00). After 1 week of acclimation in the holding tank, fish were selected and stocked in each pond at the rate of 25 per pond. Before stocking, mean weight±SE of fish in each pond was obtained and thereafter, mean weights were obtained on a weekly basis. The experimental period lasted for 16 weeks. At the end of the experiment, the ponds were drained and all fish in each pond counted.

Fish growth and survival performance: Fish percentage weight gain and Specific Growth Rate (SGR) at the end of the experiment in each treatment pond were calculated using the following formulae as described by Brown (1957) and Winberg (1956) respectively:

$$\text{Weight gain (\%)} = \frac{W_2 - W_1}{W_1} \times 100$$

$$\text{SGR (\%/day)} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1} \times 100$$

Where W_2 and W_1 are final weight (g) at time t_2 (days) and initial weight (g) at time t_1 (days) respectively.

Fish percentage survival at the end of the experiment in each treatment pond was calculated using the formula described in Kang'ombe *et al.* (2006).

$$\text{Survival rate (\%)} = \frac{N_1 - N_2}{N_1} \times 100$$

Where N_1 and N_2 are initial number of fish stock in pond and number of dead fish respectively.

Water quality monitoring: During the experimental period water physico-chemical parameters in each pond were monitored on a weekly basis using standard methods as described by APHA (1985). Parameters monitored include the following: temperature, total alkalinity, dissolved oxygen, free carbon dioxide, pH, phosphate, nitrate and ammonia.

Statistical analysis: The data was first checked for assumptions for analysis of variance. The data was then subjected to analysis of variance (ANOVA) using a General Linear Model (GLM), repeated measures design on weight measurements with time. One-way ANOVA analysis was then performed at each time for weight and other data collected to determine significance. If significant ($p<0.05$) differences were found in the ANOVA test, Duncan's multiple range test (Duncan, 1955) was used to rank the groups. The data are presented as mean±SE or otherwise stated, of three replicate groups. All statistical analyses were carried out using the computer package; Microsoft® Office Excel 2007.

RESULTS

Water temperature varied within a narrow range of 26.10 -26.56^{o}C throughout the experimental period. There were no marked variations in temperature between the various treatments and control groups observed at any given point of time (Table 3).

The range of dissolved oxygen in all the experimental tanks throughout the period of experiment was 1.50-15.30 mg/l (appendices 6 and 22 respectively) with mean values of 7.77±0.47, 7.84±0.38, 8.92±0.44 and 7.77±0.56 mg/l for control, LCPD, MCPD and HCPD respectively. At weeks 0, 2, 6, 10 and 14, there was no significant difference ($p>0.05$) between the treatments and control; however, a significant difference ($p<0.05$) was observed with increase in the duration of the experiment. During the experimental period, values of free carbon dioxide ranged between 0.00 and 0.75 mg/l. Tank HCPD had the highest mean of 0.15±0.370 mg/l followed by tanks MCPD, LCPD and control respectively with ranges 0.10±0.03, 0.07±0.00 and 0.05±0.02 mg/l. The range of total Alkalinity was from 32.90-102.00 mg/l, the highest mean was recorded in tank LCPD that had 74.51±2.30 mg/l followed by tanks MCPD, HCPD and control respectively, which had 70.96±2.74, 70.15±2.81 and 63.63±2.82 mg/l. Throughout the period of experiment pH values ranged between 7.05-11.06. While HCPD tank recorded the highest mean of 9.59± 0.11, control tank recorded the lowest mean of 8.99± 0.16. MCPD and LCPD tanks recorded pH values of 9.50 ±0.10 and 9.20±0.10 respectively. The range values for phosphate throughout the experimental period was 0.01-0.09 mg/l. (appendices 22 and 24 respectively) Mean values for control, LCPD, MCPD and HCPD tanks were 0.03±0.01, 0.03±0.01, 0.05±0.01 and 0.05±0.01 mg/l respectively. Nitrate values ranged between 1.12-13.16 mg/l. The mean values for the different tanks were LCPD- 5.96±1.29 mg/l, MCPD- 8.17±1.25 mg/l, HCPD-9.34±1.47 mg/l and control tank 1.51±0.14 mg/l. The range for Ammonia was 0.00-0.85 mg/l. The mean values in the different tanks were 0.29±010, 0.45±0.13, 0.55±0.13 and 0.18±0.06 mg/l for tanks LCPD, MCPD, HCPD control respectively.

A checklist of the different types of plankton recorded in the dung treated tanks is presented as Table 6.

Significant difference ($p<0.05$) in the growth of the experimental fish was observed in all treatments and the control groups of fish (Table 4). Fish in the control tanks recorded the highest growth with 149.10% gain in weight. Among the various treatments, highest growth was observed in fish grown in HCPD which compared favourably with growth recorded in the control groups (Fig. 1) at the end of the experimental period. Among the various treatment groups, fish grown in HCPD tanks recorded the highest growth with 123.49% gain in weight; this was then closely followed by fish in the MCPD, while those in LCPD recorded the least growth with 115.11% and 55.40% weight gain respectively (Table 4).

Table 5 represents the nutrient composition of fish carcass before and after the experimental period. The lowest crude protein value (11.29%) was recorded in fish reared in LCPD tank ($p<0.05$); while the highest value (14.01%) was recorded in fish grown in the control tank ($p<0.05$). Value of crude protein recorded in fish grown in LCPD after the experimental period was not significant ($p>0.05$) when compared to value before the experimental period. Fish grown in the LCPD experimental tank had the lowest (72.7%) moisture content while those grown in MCPD tanks recorded the highest (74.63%) value, although all values recorded after the experimental period were not significantly different ($p>0.05$). Lipid content in the experimental fish before their introduction into the various treatment tanks was significantly higher ($p<0.05$) than values recorded after the experimental period. Lowest lipid value (2.44%) was recorded in fish grown in the control tank and highest (2.93%) in fish grown in HCPD tanks.

Figure 2 represents the survival of the fish in the various tanks. The highest mean mortality was recorded in tanks LCPD which had 86% survival, while the least mortality was recorded in both the control and HCPD experimental tanks with 96% survival each. Statistically, there were no significant differences ($p<0.05$) among the values of survival recorded.

DISCUSSION

In the present study, the physico-chemical parameters remained within favourable ranges for fish growth and survival. Dissolved oxygen can be said to be the most important among the water quality parameters without which fish production is impossible. Desirable concentration of dissolved oxygen for most fish is 5 mg/l and above and the concentrations recorded in all the tanks used in this study has been within this range.

Table 3: Mean values (±)* of water quality parameters in various experimental tanks during period of investigation

	Treatment				
Parameters	LCPD	MCPD	HCPD	Control	P-value
DO (mg/l)-day	7.84±0.38^{a}	8.92±0.44^{b}	7.77±0.56^{a}	7.77±0.47^{a}	p<0.01
DO (mg/l)-Night	5.28±0.95^{a}	6.91±1.03^{b}	6.82±0.14^{c}	6.80±1.08^{c}	p<0.01
FCD (mg/l)-Day	0.07±0.02^{a}	0.10±0.03^{b}	0.15 ±0.034^{c}	0.05±0.02^{a}	p<0.01
FCD (mg/l)-Night	1.04±0.02^{a}	1.00±0.07^{b}	0.98±0.02^{c}	1.00±0.01^{b}	p<0.001
TA (mg/l)	74.51± 2.30^{a}	70.92±2.74^{b}	70.15±2.81^{b}	63.63±2.82^{c}	p<0.01
pH (mg/l)	9.20±0.10^{a}	9.50±0.10^{b}	9.59±0.11^{b}	8.99±0.16^{c}	p<0.05
Phosphate (mg/l)	0.03±0.01^{a}	0.05±0.01^{b}	0.05±0.01^{b}	0.03±0.01^{a}	p<0.01
Nitrate (mg/l)	5.96±1.29^{b}	8.17±1.25^{c}	9.34±1.47^{d}	1.51±0.14^{a}	p<0.01
Ammonia (mg/l)	0.29±0.10^{a}	0.45±0.12^{b}	0.55±0.13^{c}	0.18±0.06^{a}	p<0.05
Temp (°C)-day	26.10±0.37^{a}	26.28±0.34^{a}	26.33±0.35^{ab}	26.56±0.34^{b}	p<0.001
Temp (°C)-Night	26.13±0.48^{b}	25.25±0.48^{a}	26.13±1.18^{b}	26.25±0.96^{b}	p<0.001

*Values with different superscripts in a row are significantly different (p<0.05). DO-dissolved oxygen, FCD-free carbon dioxide, TA-total alkalinity

Table 4: Mean values (±)* growth indices of *O. niloticus* in control and treated tanks

	Treatments				
Parameters	LCPD	MCPD	HCPD	Control	P-value
Mean initial weight (g)	2.78 ± 0.02^{a}	2.78 ± 0.12^{a}	2.81 ± 0.03^{a}	2.77 ± 0.04^{a}	p<0.001
Mean final weight (g)	4.32 ± 0.14^{a}	5.98 ± 0.09^{b}	6.28 ± 0.25^{bc}	6.90 ± 0.12^{c}	p<0.001
Weight gain (g)	1.54 ± 0.00^{a}	3.20 ± 0.06^{b}	3.47 ± 0.01^{b}	4.13 ± 0.14^{c}	p<0.001
Weight gain (%)	55.40 ± 1.47^{a}	115.11 ± 2.12^{b}	123.49 ± 5.11^{c}	149.10 ± 1.11^{d}	p<0.001
Specific growth rate (%/day)	0.31 ± 0.00^{a}	0.54 ± 0.01^{b}	0.57 ± 0.00^{c}	0.64 ± 0.06^{d}	p<0.001

*Values with different superscripts in a row are significantly different (p<0.05)

Table 5: Mean values (±)* of Nutrient composition (% wet weight) of carcass of *O. niloticus* before and after experimental period in control tanks and those fertilized with different concentration of pig dung

		After				
Nutrient	Before	Control	LCPD	MCPD	HCPD	P-value
Moisture content	71.56±2.07^{a}	73.53±3.00^{b}	72.7±1.08^{ab}	74.68±3.09^{c}	74.34±1.04^{c}	p<0.01
Ash content	2.32±0.09^{a}	2.96±0.00^{c}	2.73±0.01^{ab}	2.78±0.01^{ab}	2.86±0.00^{c}	p<0.001
Crude protein	10.69±0.15^{a}	14.01±0.17^{c}	11.29±0.91^{a}	12.89±0.01^{ab}	12.93±0.17^{ab}	p<0.01
Lipid	5.90±0.00^{b}	2.44±0.00^{a}	2.65±0.03^{a}	2.79±0.00^{a}	2.93±0.01^{a}	p<0.001

*Values with different superscripts in a row are significantly different (p<0.05)

Table 6: A checklist of most common plankton observed in experimental tanks

Phytoplankton	Zooplankton
Chlorophyta	Cladocera
Chlorogonium elongatum	*Ceriodaphnia comuta*
Volvox tertius	*Moina micrura*
Chlorella vulgaris	
Crucigenia rectangularis	Rotifera
Scenedesmus quadricauda	*Brachionus variabilis*
	Brachionus leydigi rotondus
Euglenophyta	*Brachionus urceolaris bennini*
Euglena convulata	
Phacus curvicauda	
Chrysophyta	
Gyrosigma acuminatum	
Navicula digitoradiata	

Ammonia usually reaches pond water as a product of fish metabolism and decomposition of organic matter by bacteria. The greatest concentrations of total ammonia nitrogen usually occur after phytoplankton die offs. In water, ammonia nitrogen occurs in two forms, un-ionized ammonia and ammonium ion. Un-ionized ammonia is toxic to fish, but the ammonium ion is harmless except at extremely high concentrations. The toxic levels for un-ionized ammonia usually lie between 0.6-2.0 mg/l for fish pond. In this study the major cause of entry of ammonia into the treated tanks was through the decomposition of organic matter (pig dung) and fish metabolism while in the control tank it was only through fish metabolism. No phytoplankton die offs occurred during the period of this study. The range (0.00-0.85 mg/l) of ammonia that was observed can be said to be within the range of safety. There was a significant difference (p<0.005) in the concentration of ammonia in the tanks between the time intervals. This was as a result of increase in cumulative load of the manure with time whereby higher concentrations were recorded as period of experiment increases.

Nitrogen and phosphorous are some of the major nutrient components in animal manure (Das *et al*., 2005). The final product of the decomposition of organic nitrogen and phosphorus compounds in aerobic medium are referred to as nitrates and phosphates. Nitrates are generally present in small concentrations in all surface waters, but ponds receiving pig dung is likely

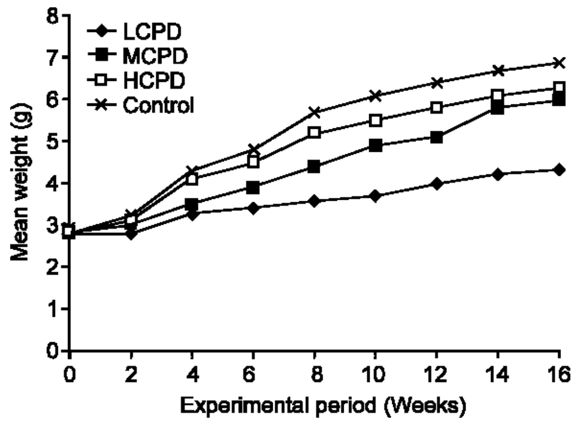

Fig 1: Mean weight over time of the Nile tilapia, *Oreochromis niloticus* grown in experimental tanks fertilized with different levels of pig dung for 16 weeks

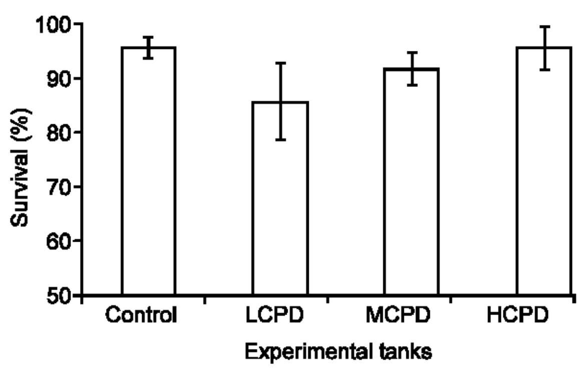

Fig 2: Survival of the Nile tilapia, *Oreochromis niloticus* grown in experimental tanks fertilized with different levels of pig dung for 16 weeks

to have a higher concentration. The toxicity of nitrates to fish is very low because toxic action of nitrates is only recorded when their concentration is above 1000 mg/l (Sharma, 1989). The range of mean values recorded in this experiment was 1.12-13.16 mg/l which falls within favourable range for fish survival and growth. The lowest value (1.12 mg/l) was recorded in the control tank, which was expected as it did not receive any input of dung while the highest value (13.16 mg/l) recorded in HCPD was due to high input of dung.

Phosphates in pig dung are generally very low; hence, the mean values obtained in the present study ranged between 0.03-0.05 mg/l. Dhawan and Kaur (2002) reported the correlation of amount of phosphate in fish pond receiving pig dung with the level of pig input, noting that ponds receiving high levels of pig dung generally will have correspondingly higher levels of organic phosphate.

Sharma (1989) also recorded higher levels of phytoplankton in ponds receiving pig dung, as observed in this study. Morris and Mischke (1988) reported that phytoplankton populations alone do not necessarily increase zooplankton populations as zooplankters will eat more fungi and bacteria associated with decaying organic substances than phytoplankton directly. The dynamic characteristics of zooplankton populations have led researchers to use particular fertilization techniques and species-specific zooplankton inoculations in culture ponds so as to maintain high densities of desirable zooplankton species in culture ponds. From the foregoing, the higher representation of phytoplankton diversity observed in this study as compared to lower zooplankton diversity could be that zooplankton did not feed exclusively on phytoplankton thereby giving room for more phytoplankton reproduction.

One of the major causes of mortality in fish production is pollution. If pollution was to occur due to daily application of the dung, it would have been higher in HCPD tank as it received the highest input, in which higher mortality would also have been recorded in the tank. However, the percentage of mortality in HCPD tank was the lowest (4%). This corroborate earlier report of Sharma and Das (1988) who noted that addition of pig manure at appropriate levels in fish ponds do not have adverse effect on water quality. Hence this report implies that pollution is likely not to occur due to the pig manure application if other conditions are not distorted.

The high percentages of survival of *O. niloticus* recorded in all the tanks closely agree with the findings of Baotong *et al.* (1983) and Dhawan and Kaur (2002). Although in their studies, different species of fish were used, they reported 90.70% and 100% survival respectively. Although the survival of *O. niloticus* between the concentrations was not significantly different at $p>0.05$, the lowest survival percentage recorded in LCPD tank may be attributed to lower dung input in the tank. And since water was added frequently to all the tanks to maintain constant water level, it is possible that algal blooming was not adequate enough to balance up thereby causing shortage of food.

Generally, weight gain by *O. niloticus* in all the tanks was observed to be increasing with increase in duration of the experiment. Values of weight gain and specific growth rate all showed similar growth rate pattern in the treated tanks with fish grown in PDHC tank having the highest values followed by those grown in MCPD and LCPD tanks. The growth of fish recorded in the PDHC tanks compared favourably with those in the control tanks that were feed with formulated diets. The range of SGR (0.31-0.57% day) recorded in fish grown in the treatment tanks from this investigation is with the range recorded by various authors for tilapia species grown in other types of animal manure. Kang'ombe *et al.* (2006) recorded a SGR of 0.42 and 0.43 %/day for *Tilapia rendalli* grown in ponds enriched with cattle and pig manure respectively. However, the range is lower than value recorded by Chaula *et al*. (2002) for *Oreochromis shiranus* grown on similar animal manure; these authors reported a value of 0.70 %/day. In same manner, Garg and Bhatnagar (2000) reported higher value (0.71 %/day) for the Indian major carp, *Cirrhinus mrigalle* grown in ponds enriched with mixture of cow dung, triple superphosphate and urea. In a comparative study with silver carp, bighead carp, common carp and tilapia in a polyculture system, Baotong *et al*. (1983), observed that pig manure resulted in a better fish growth than both cattle and chicken manure.

At the beginning of experiment, the carcass nutrient composition showed no significant difference ($p>0.05$) while a significant difference ($p<0.05$) was observed at the end of the experiment. This could be as a result of the differing concentration of the dung going into the treatment tanks. Even as no supplementary feed was given at any time to the fish in the treated tanks, the performance of the fish in all the treated tanks was not poor as compared to those in the control tanks, which received supplementary feeding throughout the duration of the experimental. Kang'ombe *et al*. (2006) observed similar results when *Tilapia rendalli* was cultured using different organic animal manure. Results from this investigation support earlier findings of Yi *et al*. (2002) who noted that amount of protein in fish grown in organically enriched ponds do not decrease significantly when compared to fish grown on supplementary feeding.

In recent times, a lot of households keep pig for domestic consumption. This is because of the value of its flesh, but its wastes can also be put to use in the rearing of fish. This is done by the fertilizing of ponds in order to instigate bloom of algae (autotrophs) mostly phytoplankton. Fish and other microorganisms (zooplankton) will in turn feed on the resultant phytoplankton. *O. niloticus,* like many other herbivorous fish species which feeds mainly on phytoplankton, can therefore be regarded as a good candidate for good production in fertilized ponds.

Furthermore, for sustainable aquaculture there should be, to a large extent dependency upon eco-friendly and economically and socially viable culture systems. Hence the recycling of organic wastes for fish culture comes in handy as it serves the dual purpose of cleaning the environment by avoiding the problem of waste disposal and providing economic benefits through reduced expenditure on costly feeds and inorganic fertilizers which form more than 50% of the total input cost in fish farming business.

REFERENCES

American Public Health Association (APHA), 1985. Standard Methods for Examination of Water and Wastewater, 16th Edn., APHA, Washington, DC.

Association of Official Analytical Chemists (AOAC), 1990. Official Methods of Analysis of the Association of Official Analytical Chemists. 14th Edn., AOAC, Washington DC.

Baotong, H., W. Tingting, F. Yingxue, D. Jiayi and G. Xianzhen, 1983. Preliminary Studies on the effects of three animal manure on the ecological conditions of pond water and fish growth. Food and Agricultural Organization, Rome. NACA/WP/83/9.

Boyd, C.E. and C.S. Tucker, 1998. Pond Aquaculture Water Quality Management. Kluwer Academic Publishers, Boston.

Brown, M.E., 1957. Experimental studies on growth. In: Hoar, W.S., Randell, D.J. (Eds.), Physiology of Fishes. Academic Press, New York, pp: 361-400.

Chaula, K., D. Jamu, J.R. Bowman and K.L. Veverica, 2002. Effect of stocking size and nutrient inputs on the productivity of *Oreochromis shiranus* in ponds. In: McElwee, K. Lewis, K. Niddifer, M. and Buitrago, P. (Eds.) Pond Dynamics/Aquaculture CRSP, Nineteenth Annual Technical Report, Oregon State University, Corvallis, OR, pp: 161-166.

Das, P.C., S. Ayyappan and J. Jena, 2005. Comparative changes in water quality and role of pond soil after application of different levels of organic and inorganic inputs. Aquacult. Res., 36: 785-798.

Dhawan, A. and S. Kaur, 2002. Pig dung as pond manure: Effect on water quality, pond productivity and growth of carps in polyculture system. Naga, the ICLARM Quarterly, 25: 11-14.

Duncan, D.B., 1955. Multiple range and multiple F-tests. Biometrics, 11: 1-40.

Garg, S.K. and A. Bhatnagar, 2000. Effect of fertilization frequency on pond productivity and fish biomass in still water pond stocked with *Cirrhinus mrigala* (Ham.). Aquacult. Res., 31: 353-369.

Gupta, M.V., M. Ahamed, A.A. Bimbao and C. Lightfoot, 1992. Socioeconomic impact and farmers' assessment of Nile tilapia, *Oreochromis niloticus* culture in Bangladesh. International Center for Living Aquatic Resources Management, Manila, Philippines. ICLARM Technical Report 35.

Hepher, B. and Y. Pruginin, 1982. Tilapia culture in ponds under controlled conditions. In: Pullin, R.S.V. and Lowe-McConell, R.H. (Eds.), The Biology and Culture of Tilapias.. International Center for Living Aquatic Resources Management, Bellagio, ICLARM Conference Proceedings, 7: 185-203.

Kamanga, L. and E. Kaunda, 1998. The effect of different types of manure on zooplankton abundance and composition in relation to culture of *Oreochromis shiranus* (L). In: Likongwe, J.S. and Kaunda, E. (Eds.), First Regional Workshop on Aquaculture. Proceedings of the First Regional Workshop on Aquaculture, held at Bunda College of Agriculture, Lilongwe, Malawi, 1-19 November 1997 pp: 45-56. University of Malawi, Lilongwe, Malawi.

Kang'ombe, J., J.A. Brown and L.C. Halfyard, 2006. Effect of using different types of organic animal manure on plankton abundance and on growth and survival of Tilapia rendalli (Boulenger) in ponds. Aquacult. Res., 37: 1360-1371.

Knud-Hansen, C.F., 1998. Pond Fertilization: Ecological Approach and Practical Application. Pond Dynamics/Aquaculture Collaborative Research Support Program. Oregon State University, Corvallis, OR.

Knud-Hansen, C.F., T.R. Batterson and C.D. McNabb, 1993. The role of chicken manure in production of Nile tilapia, *Oreochromis niloticus*. Aquacult. Fish. Manag, 24: 483-493.

Morris, J.E. and C.C. Mischke, 1988. Plankton Management for Fish Culture Ponds. Iowa State University, Ames, IA, USA. Technical Series No. 114.

Nguenga, D., J.J. Breine, S.S. Yong, G.G. Tuagels and F. Ollevieer, 1997. Effect of animal manure and chemical fertilizer on the growth and survival of *Tilapia cameronensis* Holly in Cameroon. Aquacult. Res., 28: 231-234.

Okoye, F.C., 1996. Fertilizer Application in Ponds. National Institute for Freshwater Fisheries Research, Nigeria. Extension Guide Series No.4.

Pullin, R.S.V. and M. Prein, 1995. Fishponds facilitate natural resource management on small scale farms in tropical developing countries. In: Symoens, J.J. and Micha, J.C. (Eds.), The Management of Integrated FreshwaterAgro-Piscicultural Ecosystems in Tropical Areas. International Centre for Living Aquatic Resources Management, Manila. ICLARM No. 1051, pp: 169-186.

Sharma, B.K., 1989. Fish culture integrated with various systems of livestock farming. I. Fish-cum-pig, II. Fish-cum-duck, III. Fish-cum-poultry, IV. Fish-cum-cattle, Compendium of Lecture No. 2 of Training programme on Integrated Fish Farming, 12-31 January 1989, CIFA (ICAR), Bhubneshwar.

Sharma, B.K. and M.K. Das, 1988. Studies on integrated fish-livestock carp farming system. Fishing Chimes 7: 15-27.

Swift, D.R., 1993. Aquaculture Training Manual, 2nd edn. Fishing News Books, Garden-Walk Farnham, Surrey.

Wohlfarth, G.W. and G. Hulata, 1987. Use of manure in Aquaculture. In: Moriatry, D.J. and Pullin, R.S.V. (Eds.), Detritus and Microbial Ecology in Aquaculture. International Center for Living Aquatic Resources Management, Manila, ICLARM Conference Proceedings, 14: 353-367.

Winberg, G.G., 1956. Role of metabolism and food Requirement of fishes. Belorussian State University, Minsk. (Translated from Russian by J. Fish. Res. Bd. Can. Translation Service, 194: 202.

Yi, Y., C. Kwei Lin and J.S. Diana, 2002. Semi-intensive culture of red tilapia in brackish water ponds. In: In: McElwee, K. Lewis, K. Niddifer, M. and Buitrago, P. (Eds.) Pond Dynamics/Aquaculture CRSP, Nineteenth Annual Technical Report, Oregon State University, Corvallis, OR, pp: 88-96.

Yun, Z., Y. Yejin, W. Junhua and H. Dan, 1987. Primary Studies on Frequencies of Fertilization of fishponds. Network of Aquaculture Centre in Asia, Bangkok. NACA/WP/87/50.