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Effect of processing pig manure in a biodigester as fertilizer input for ponds growing fish in polyculture

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Abstract

An experiment was conducted in the Fish Farm at the School of Agriculture Prek Leap, Cambodia from May 01, 2001 to August 20, 2001 in order to compare the effects of pond inputs - fresh pig manure, biodigester effluent and chemical fertilizer (control) on the growth of fish and water quality. Nine ponds were used for this experiment, with surfaces that ranged from 45 to 65 m² and 1 m depth. Five fish species were stocked at a density of 2 fish/ m²: Tilapia, Silver carp, Bighead carp, Silver barb and Mrigal in the percentages of 35, 30, 15, 15 and 5%, respectively. The same quantity of nitrogen was applied to each pond, based on a loading rate with pig manure dry matter of 6 g /m²/day, equivalent to 103 mg N/m²/day.

All of the five fish species (Tilapia, Silver carp, Bighead carp, Silver barb and Mrigal) grew faster in ponds fertilized with effluent than with manure, but the degree of response was highest for Silver Carp, Bighead carp and Tilapia and least for Mrigal. The net fish yield was 55% greater in ponds fertilized with biodigester effluent rather than with fresh manure. The improvement with effluent compared with chemical fertilizer was 27%.

Dissolved oxygen concentrations were significantly increased when the ponds were fertilized with effluent compared with fresh manure. Thus the principal benefit of prior anaerobic digestion of pig manure appears to be the decrease in the BOD (biological oxygen demand) in the effluent due to removal of carbon as methane in the digestion process.

The recovery of nitrogen in the fish from the nitrogen in the fertilizer was 42% for the biogester effluent, 26% for the manure and 37% for the mixture of urea and di-ammonium phosphate.

Key words: Ponds, biodigester, effluent, pig manure, chemical fertilizer, fish, polyculture, survival rate and water quality

Introduction

Poverty, population growth and environmental degradation (air, soil and water pollution) are increasingly being considered as focal points for research and development. The integration of livestock with trees, food crops and aquaculture is seen as the most appropriate way to use the natural resources in a system that is productive and sustainable (Preston 2000). In such a system the processing of the livestock manure by anaerobic digestion is a key component as it has many positive features such as reduction in emission of methane (a major actor in global warming), decrease in pathogens (better health of people and animals), production of biogas for cooking (reduced pressure on forests for fuel wood; more comfortable working conditions in the kitchen for women) and improved nutrient recycling (reduced need for chemical fertilizer).

The main products from the biodigester are biogas and effluent. The latter has considerable potential as fertilizer because the anaerobic digestion process results in conversion of organic nitrogen in the manure to ionized ammonia (NH_4^+) which can be used directly by plant roots. Despite the potential for improved fertilizer capacity of effluent compared with raw manure there are few reports of trials to compare the two sources of plant nutrients. In Vietnam, Le Ha Chau (1998a,b) showed that the effluent from biodigesters charged with cattle or pig manure was superior to the fresh manure when applied to plots growing forage cassava and ponds growing duckweed. In both cases biomass yield and protein content were increased by the effluent compared with the fresh manure. Increased productivity in polyculture fish ponds when biodigester effluent, rather than manure, was used as fertilizer was reported by Han Yuqin and Ding Jieyi (1983). Yields of fish were increased by 26% when the effluent was applied compared with the original manure.

The following experiment was carried out to obtain further evidence concerning the apparently superior fertilizer value of biodigester effluent, compared with fresh manure, when used in polyculture fish ponds.

Objectives

The objective was to compare fresh pig manure with biodigester effluent, derived from the same manure, as the source of nutrients in polyculture fish ponds.

Materials and methods

Treatments and design

Nine ponds with areas ranging from 45 to 65 m² and a depth of 1m were used. Three fertilizer treatments were applied to each of three ponds according to a random block design (Table 1). The treatments were:

- PM: Fresh pig manure
- PE: Biodigester effluent from a biodigester charged with the same pig manure as used for PM
- U-DAP: Mixture of 80% urea and 20% diammonium phosphate

Table 1: Allocation of the treatments to the ponds

	Block 1			**Block 2**			**Block 3**	
PE	U-DAP	PM	PM	U-DAP	PE	PM	PE	U-DAP

Installation and management of the biodigester

Installation

A plastic biodigester (Bui Xuan An et al 1997) was installed on the 9th of March 2001, in the Fish farm at the School of Agriculture, Prek Leap in order to collect the effluent for conducting the experiment. A trench was dug near the guard house, with the following dimensions; width at the top 90 cm, depth 90 cm, width at the bottom 70 cm and length 7 m. The total volume of this biodigester was about 5.5 m³. Normally, the liquid fraction is about 80% of the total tube volume which is equivalent to 4 m³. A hole was dug at the outlet of the biodigester to collect the effluent and a roof was erected to protect against the rain.

Management

The biodigester was loaded initially with 392 kg of fresh pig manure. After a period of 19 days a further 100 kg were added and subsequently varying amounts were added at 2 to 3 day intervals, the aim being to achieve an average loading rate of about 15 kg fresh manure per day. At each loading water was added to the fresh manure to give a total solids content of about 10%.

Management of the ponds

All ponds were spread with quick-lime (CaO) at 1 kg/10m², 10 days before stocking with fish. This was to eliminate parasites and pathogenic organisms and to increase the pH. The ponds were filled with water 3 days after liming. Each pond was stocked with five fish species at a density of 2 fish/m². The relative proportions of the different species were: Tilapia *(Oreochromis niloticus)*: 35%, Silver carp *(Hypophthalmichthys molitrix)*: 30%, Bighead carp *(Aristichthys nobilis)*: 15%, Silver barb *(Puntius gonionotus)*:15% and Mrigal (*Cirrhinus mrigal)*: 5%. The Tilapia, Bighead carp, Silver carp and Silver barb were available from the fish farm in the School of Agriculture, Prek Leap. The Mrigal fry were purchased from the Scale fish hatchery.

The fertilizer treatments were applied 3 days after stocking the fish. The amounts of the inputs (U-DAP, PM and PE) were calculated to be iso-nitrogenous based on the nitrogen present in a loading rate for fresh pig manure of 15 g dry matter/m^2. However, at this rate of application the fish in the ponds receiving the treatment receiving fresh pig manue gulped for air in the early morning. The total quantities (Table 2) were then adjusted on the basis of applying 6 g dry matter (as fresh pig manure)/m^2 per day, given in amounts of 18 g every third day.

Table 2: Total quantities of fertilizer added to the ponds over a 152 day period

Pond No:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Area, m^2	57	59	60	50.5	60.5	65	55	62.5	45
Fresh pig manure, kg			122	102			111		
Effluent, litres	2070					2356		2271	
Urea, kg		1.3			1.37				1.02
DAP, kg		0.323			0.331				0.246
Total N, kg	0.704	0.672	0.753	0.634	0.690	0.80	0.692	0.781	0.513
N, mg/ m^2/day	117	108	119	119	108	117	119	117	108

Measurements

The weight and length of the fish were determined every 20 days in the morning at 8 am before loading the fertilizer. The fish were caught with a seine net. Ten fish of each species were taken as the sample. The fish were put in a plastic bag and weighed. The length from the tip of the mouth to the caudal fin was measured with a ruler. At the end of the experiment the total fish biomass was harvested and the weight and length were recorded.

Samples of fresh pig manure and the corresponding effluent were taken every 15 days and analysed for nitrogen and ammonia, using a Foss-Tecatur kjeldahl apparatus (AOAC 1990), and for dry matter by micro-wave radiation (Undersander et al 1993).

The oxygen level of the pond water was measured one day a week, two times during the day in the early morning at 6 am and in the afternoon at 2 pm. “Winkler” test-kits (Aquamerck) were used for the measurement. Water samples were collected at the same place in each pond at 20 cm depth and analyzed one by one. The pH of the pond water was measured two days a week, two times a day, in the morning at 9 am and in the afternoon at 4 pm. A pH meter with glass electrode was used for this measurement.

Water temperatures were measured five days a week, three times a day in the morning at 6 am, at 12 am and in the evening at 5 pm at a water depth of 20 cm. The thermometer was put into the pond water and left for 2-3 minutes, after which the reading was taken with the thermometer still in the water. Water transparency was measured every day in the mid day by Secchi disk.

Statistical analysis

Daily increases in weight and length of the fish were determined by linear regression with days as the independent variable. The data were analyzed by Analysis of Variance (ANOVA) using the General Linear Model software of Minitab version 12.21, and the Tukey test for checking differences among the treatment means. Variables were fertilizer treatments, fish species and error.

Results and discussion

The biodigester sub-system

The dry matter of the pig manure, in samples taken at approximately two week intervals, varied in the range 29.6 to 41.8% with corresponding contents of N of 1.65 to 1.86% in DM (Table 3). The N content of the effluent during the same period ranged from 290 to 470 mg N/litre. The ammonia-N in the effluent varied in the range 223 to 484 mg/litre. The average amount of fresh pig manure added to the biodigester was 46±2.8 kg (excluding the initial charge of 392 kg) with an interval of 2 days. This resulted in a mean daily load of 15 kg including the initial charge on day 1. Water was added at the rate of 2 volumes of water per volume of manure to achieve a solids content of approximately 10%, thus the average amount of diluted manure added daily to the biodigester was about 45 litres. The liquid volume of the biodigester was estimated to be 4.0 m^3 thus the average retention time would have been of the order of 50 days.

Table 3: Levels of dry matter and nitrogen in fresh pig manure added to the biodigester and in the effluent removed from the biodigester for application to the ponds

Date	DM in manure, %	N in manure, % in fresh matter	N in manure, % in DM	N in effluent, mg/litre	Ammonia-N mg/litre
May 10, 01	35.1	0.64	1.82	350	264
May 25, 01	29.6	0.51	1.75	290	318
June 10, 01	37.1	0.667	1.8	300	262
June 25, 01	36.0	0.669	1.86	400	478
July 10, 01	41.8	0.690	1.65	470	484
July 25, 01	32.3	0.590	1.82	300	223
August 10, 01	35.0	0.590	1.82	300	250
Mean	**35.2**	**0.622**	**1.79**	344	326
SE	1.45	0.0238	0.0262	26	42

The pond sub-system

Fish growth

Overall the fastest growth rates were with the effluent fertilizer and the lowest with the fresh manure (Table 4 and Figures 1and 2). There were differences in the response of the different fish species to the fertilizer treatments. The Silver Carp and the Bighead Carp in the effluent ponds had double the growth rate compared with those in the manure ponds. Tilapia also grew faster in the effluent than in the manure ponds but the difference was less marked. In contrast, growth rates for Mrigal and Silver Barb were similar in the effluent and manure ponds. Growth rates of fish in the ponds fertilized with urea and diammonium phosphate (DAP) tended to be intermediate between those in the manure and effluent ponds

Table 4: Least square means for rates of increase in weight and length of the five fish species according to the fertilizer treatments

	Effluent	Manure	U-DAP	SEM	Prob.
Weight gain, g/day					
Tilapia	0.499	0.348	0.358	0.045	0.100
Silver carp	1.326	0.716	1.049	0.114	0.026
Bighead carp	0.572	0.207	0.276	0.078	0.035
Silver barb	0.682	0.551	0.651	0.133	0.517
Mrigal	0.946	0.831	0.996	0.004	0.451
Increase in length, mm/day					
Tilapia	0.405	0.329	0.315	0.002	0.71
Silver carp	0.958	0.604	0.811	0.006	0.021
Bighead carp	0.407	0.144	0.224	0.005	0.037
Silver barb	0.483	0.433	0.441	0.009	0.630
Mrigal	1.482	1.401	1.454	0.061	0.226

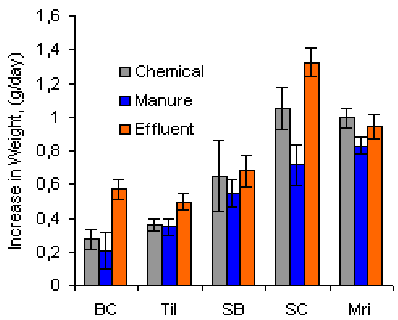

Figure 1. The daily weight gains of each fish species according to the different fertilizer treatment

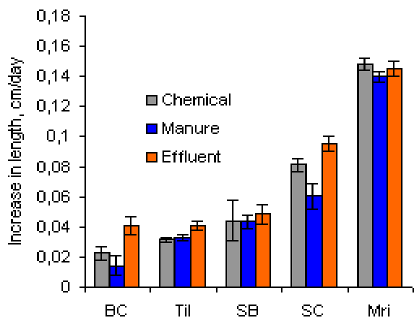

Figure 2. The daily increases in length of each fish species according to the different fertilizer treatments

Table 5: Least square means of weight and length of the five fish species according to the fertilizer treatments

Fish species	Effluent	Manure	U-DAP	SEM	Pro
Weight, g					
Tilapia	48.6	39.3	41.5	0.625	0.001
Silver carp	84.4	57.2	70.3	1.18	0.001
Bighead carp	88.4	65.2	74.4	1.80	0.001
Silver barb	55.8	47.9	55.0	1.39	0.001
Mrigal	45.1	39.7	47.6	1.66	0.007
Length, cm					
Tilapia	10.4	9.81	9.93	0.053	0.001
Silver carp	15.6	14.1	14.7	0.086	0.001
Bighead carp	16.0	14.6	15.2	0.129	0.001
Silver barb	11.5	11.3	11.5	0.090	0.219
Mrigal	9.65	9.13	9.35	0.114	0.015

Table: 6 The least square means of initial and final weights (± SE) of the five fish species according to the fertilizer tr

	Initial			Final		
	Effluent	**Manure**	**U-DAP**	**Effluent**	**Manure**	**U**
Weight, g						
Tilapia	16.5 ± 0.43	16.0 ± 0.39	15.9 ± 0.51	71.4 ± 1.76	56.4 ± 1.64	55.9
Silver carp	15.0 ± 0.36	15.4 ± 0.24	15.5 ± 0.29	143 ± 4.46	95.8 ± 3.27	116
Bighead carp	44.3 ± 2.57	45.9 ± 1.85	47.0 ± 3.29	107 ± 4.55	73.6 ± 4.69	86.9
Silver barb	18.0 ± 0.42	17.8 ± 0.42	17.0 ± 0.45	83.3 ± 4.21	77.9 ± 3.89	82.3
Mrigal	0.73 ± 0.13	0.60 ± 0.00	0.67 ± 0.07	89.6 ± 10.41	78.8 ± 5.00	94.4
Length, cm						
Tilapia	8.02 ± 0.11	7.75 ± 0.11	7.82 ± 0.16	12.2 ± 0.142	11.4 ± 0.11	11.3
Silver carp	10.1 ± 0.15	10.5 ± 0.13	10.2 ± 0.12	19.3 ± 0.27	16.5 ± 0.25	17.9
Bighead carp	13.3 ± 0.31	13.7 ± 0.19	13.4 ± 0.33	17.4 ± 0.27	15.1 ± 0.35	16.0
Silver barb	8.78 ± 0.11	8.72 ± 0.12	8.40 ± 0.12	13.4 ± 0.25	13.1 ± 0.21	13.3
Mrigal	2.6 ± 0.25	2.56 ± 0.22	2.5 ± 0.21	16.6 ± 0.73	15.7 ± 0.38	16.2

Tilapia

Tilapia grew faster in effluent and U-DAP ponds than in manure ponds (Table 5 and Figures 3 and 4). The mean weights at the end of experiment (Table 6) were 48.7, 39.3 and 41.5 g for the effluent, fresh pig manure and chemical fertilizer, respectively.

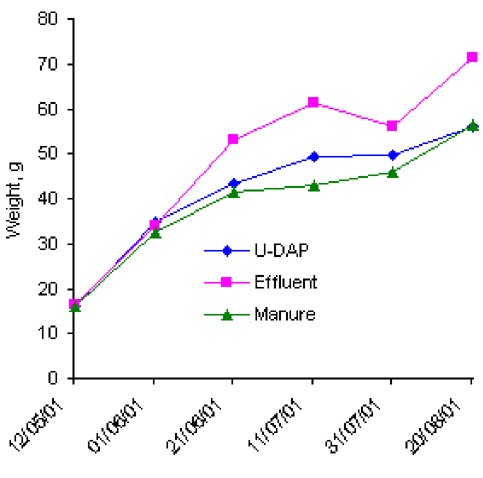

Figure 3: The growth in weight of Tilapia according to the different fertilizer treatments

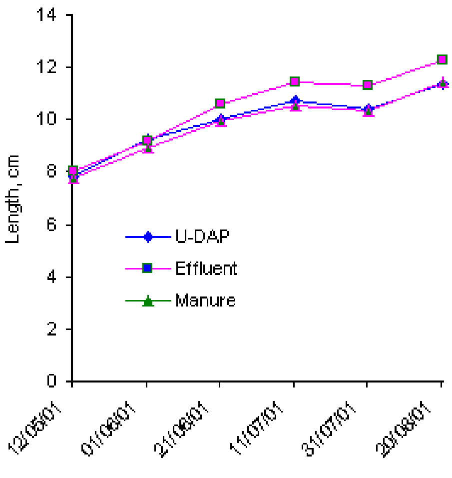

Figure 4: The growth in length of Tilapia according to the different fertilizer treatments

Silver carp grew faster in effluent and U-DAP ponds than in manure ponds (Table 5 and Figures 5 an 6). As with the Tilapia, growth was faster in the first two months and slightly slower in the third month, especially in the pig manure ponds. Compared with the other fish species, Silver carp grew very fast in the effluent pond, which probably reflected the ready availability of food for them, mostly as phytoplankton.

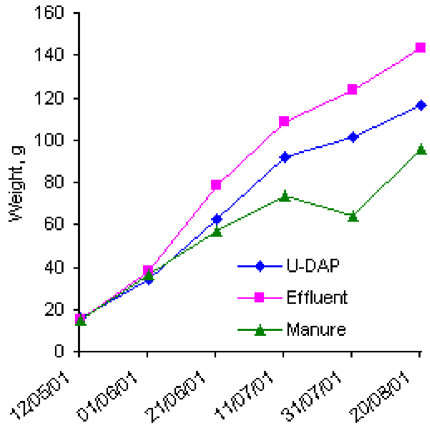

Figure 5: The growth in weight of Silver Carp according to the different fertilizer treatments

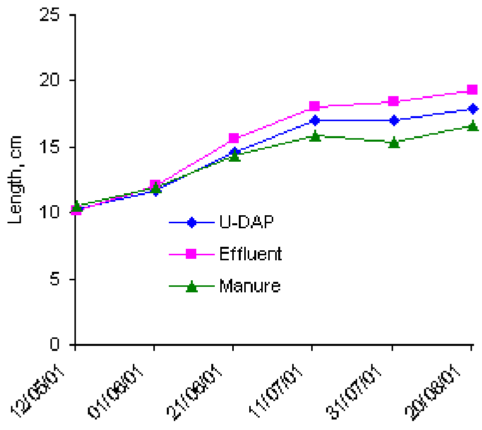

Figure 6: The growth in length of Silver Carp according to the different fertilizer treatments

Bighead carp

Bighead carp grew faster in effluent and U-DAP ponds than in the manure ponds (Table 4). The difference between effluent and manure ponds was especially noticeable (Figures 7 and 8). As with Tilapia and Silver Carp, growth rate decreased markedly after the second month.

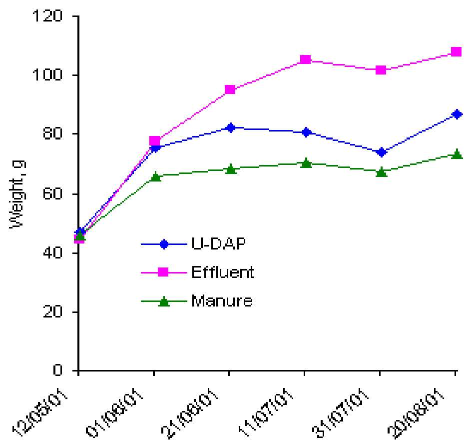

Figure 7: The growth in weight of Bighead carp according to the different fertilizer treatments

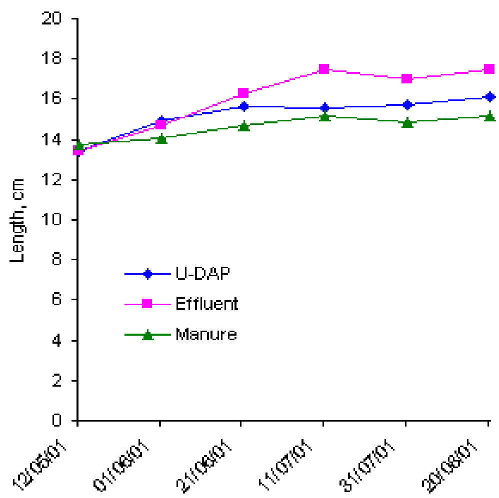

Figure 8: The growth in length of Bighead carp according to the different fertilizer treatments

Silver barb

During the first two months, the Silver barb grew at the same rate in the effluent and U-DAP ponds with slowest growth being observed in the manure ponds (Table 4 and Figures 9 and 10). However, the final weights at the end of the experiment (Table 6) showed no difference among the treatments.

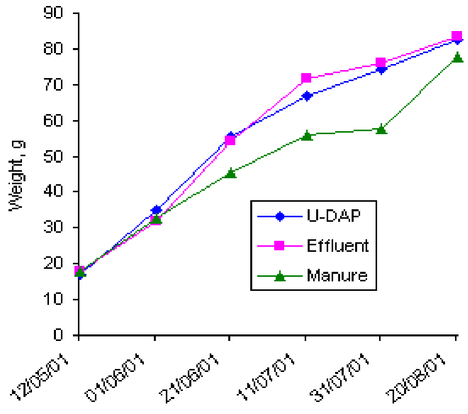

Figure 9: The growth in weight of Silver barb according to the different fertilizer treatments

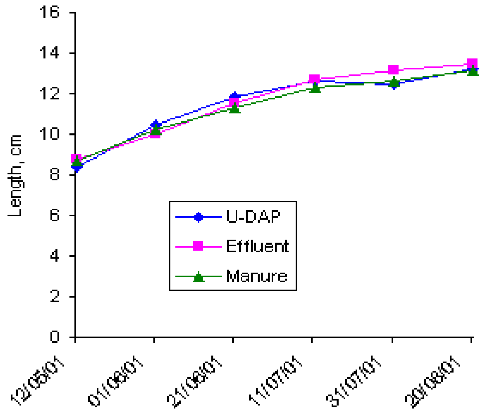

Figure 10: The growth in length of Silver barb according to the different fertilizer treatments

Mrigal

There were no differences in final weight between the fish in the effluent and U-DAP ponds but those in the manure ponds tended to be lighter. The difference was significant between DAP and the manure pond but not between effluent and manure ponds (Figure 11).

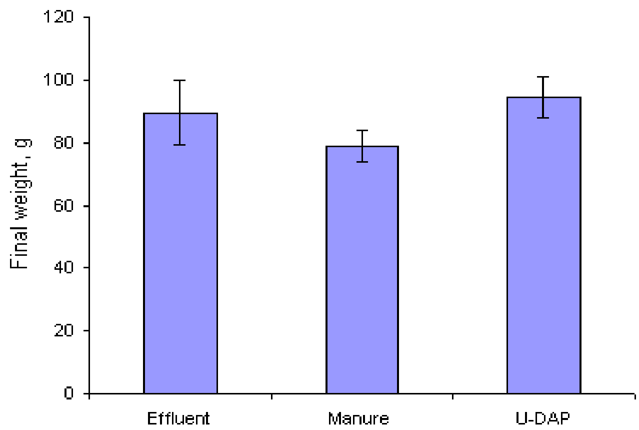

Figure 11: The mean final weight of Mrigal according to the different fertilizer treatments

Fish yield

The fish yield extrapolated to a per hectare basis was expressed as the net gain in total fish weight and the gross output (Table 7; Figure 12). There were significant differences among treatments, with highest values for the effluent treatment followed by chemical fertilizer and the manure ponds. Compared with the manure treatment, the chemical fertilizer increased net yield by 27% while the effluent treatment increased it by 55%.

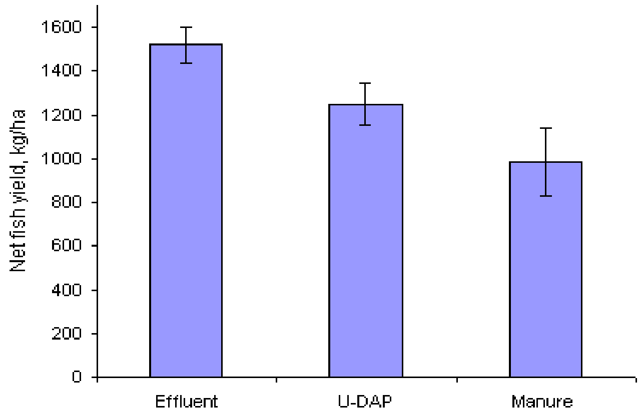

Figure 12: The net fish yield according to the different fertilizer treatments

Table 7. Mean values (with SEM) for the fish yield according to the different fertilizer treatments in the 100-day experiment.

Variable	Effluent	Manure	U-DAP	SEM	Probability
Initial weight, g/m2	39.3 ± 3.17	39.6 ± 1.38	39.7± 3.69	2.92	0.995
Final weight, g/m2	191 ± 11.2	138± 10.4	164± 11.7	11.12	0.040
Weight gain, g/m2	152 ± 8.20	98.4± 9.57	124± 15.4	11.50	0.045
Extrapolated net fish yield, kg/ha	1521± 82	984± 95.7	1248± 154	115	0.045
Extrapolated gross fish yield, kg/ha	1915 ± 112	1381± 104	1645± 117	111.23	0.040

The results from this study show that the productivity of the ponds was relatively low, if compared with the potential when pond inputs are optimized. According to Knud-Hansen et al (1991) and Lin et al (1997) the optimum inputs of nitrogen and phosphorus for fish culture are 4 kg N/ha/day and 1 kg P/ha/day or 400 mg N/m^2 and 100 mg/m^2 per day, respectively. The quantity of N recommended by these authors is almost 4 times higher than what was used in the present study (about 1 kg N/ha/day). In a report by Lin et al (1998), the growth rate of Tilapia was 0.24 and 0.30 g per day in earthen ponds loaded with 429 mg N/m^2/day and 114 mg P/m^2/day and with a stocking density of 10 and 5 fish/ m^2, respectively. In contrast, in the present study, the N application was only 108 to119 mg N/m^2/day and the growth rate of the Tilapia at a stocking density of 2 fish/ m^2 was 0.35 g/day with manure increasing to 0.5 g/day with the effluent. Thus the growth rates of the Tilapia were higher in our study but stocking rates, and hence overall productivity, was much less.

Fish survival

Overall the survival rates tended to be highest in the ponds fertilized with urea and DAP (Table 8; Figure 13) but the difference was only significant in the case of Tilapia that had poorer survival rates in the pond fertilized with fresh manure as compared with the others.

Table 8: Least square means for survival rates of the five fish species according to the fertilizer treatments

	Effluent	Manure	U-DAP	SEM	Prob.
Tilapia	87.7	72.7	91.7	3.93	0.032
Silver carp	95.3	99.0	100	1.98	0.289
Bighead carp	96.3	95.7	100	1.65	0.218
Silver barb	98.3	100	100	0.96	0.422
Mrigal	94.3	94.3	87.7	5.86	0.668

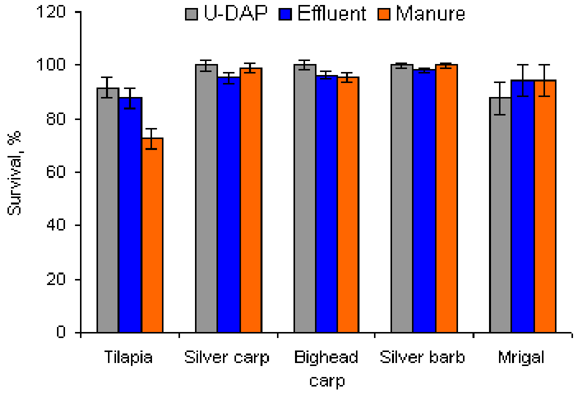

Figure 13: Survival rates of the five fish species according to the fertilizer treatments

Water quality

Table 9. Mean values of water quality parameters during the experimental period according to the fertilizer treatments

Parameters	Effluent	Manure	U-DAP	SEM	Probability
Dissolved oxygen, mg/litre					
0600 hr	2.11	1.19	1.92	0.090	0.001
1400 hr	7.13	6.22	6.62	0.213	0.012
pH					
0900 hr	7.79	7.76	7.81	0.032	0.538
1600 hr	8.66	8.39	8.66	0.030	0.001
Temperature, °C	32.0	32.1	32.0	0.132	0.880
Secchi disk depth, cm	19.4	24.1	21.1	0.515	0.001

Oxygen level

The dissolved oxygen concentration, both in early morning and afternoon, was lowest in ponds fertilized with fresh pig manure (Table 9). Values for effluent and U-DAP ponds were similar with a tendency for higher values in the effluent ponds. During most of the culture period, the oxygen concentration was less than 1mg /litre in the morning in ponds loaded with fresh pig manure (Figure 14). Differences were less marked in the afternoon, but low values for dissolved oxygen were observed in manure ponds midway through the culture period (Figure 15). According to Swingle (1969), the minimum oxygen concentration should be not less than 5 mg/ litre. Values from 0.3 to 1mg/litre over an extended period were considered to be lethal to fish and from 1mg to 5mg/litre the fish will survive, but growth will be slow. Thus it can be concluded that biodigester effluent provides better conditions for fish growth than fresh manure.

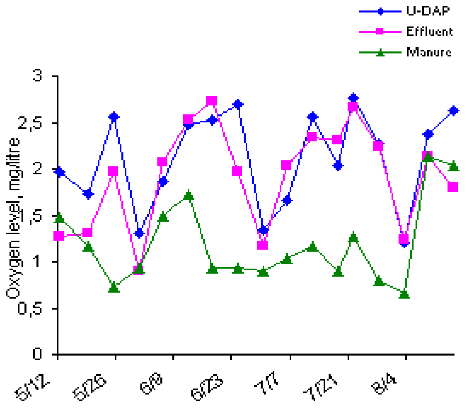

Figure 14: The fluctuation of oxygen level in the ponds at 06.00 hr, according to the different fertilizer treatments.

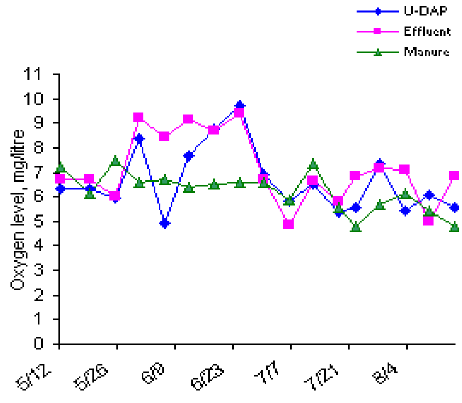

Figure 15: The fluctuation of oxygen level in the ponds at 14.00 hr, according to the different fertilizer treatments.

pH

The pH of the pond water in early morning did not differ among the treatments. In the afternoon, pH was lower (P=0.001) in the manure ponds than in those fertilized with effluent or U-DAP (Table 9). According to Swingle (1969) the appropriate pH range for good fish growth is from 6.5 to 9. The values recorded in the present study were within this range for all treatments (Figures 16 and 17).

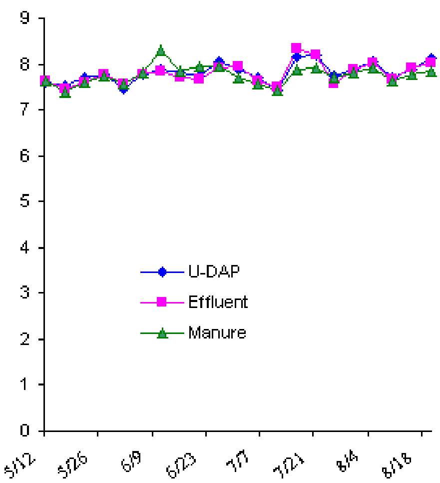

Figure 16: The fluctuation of pH in the morning (09.00 hr) according to the different fertilizer treatments

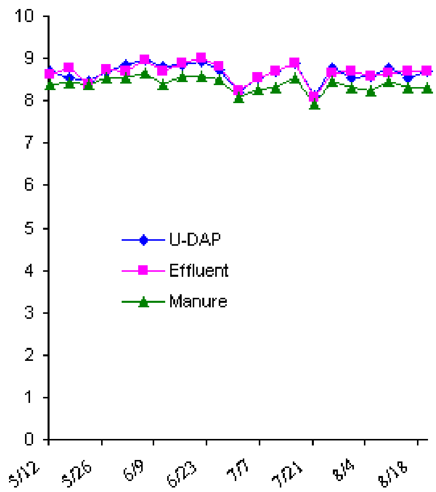

Figure 17: The fluctuation of pH in the afternoon (16.00 hr) according to the different fertilizer treatments

Water temperature

There were no differences among the treatments (Table 9; Figures 16 and 17).

Water transparency

The water transparency differed among treatments with the lowest value for the effluent, followed by thechemical fertilizer and fresh pig manure, respectively (Figure 18)

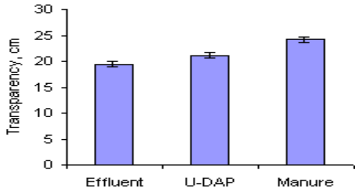

Figure 18: The mean values of water transparency according to the different fertilizer treatments

Biodigester effluent versus fresh manure

The most important finding in the present study is the 55% increase in net fish yield as a result of processing the pig manure through a biodigester. In a comparison of fresh pig manure (FPM) and biogas fermentation liquid (BFL) [presumably the liquid fraction of the biodigester effluent], in a polyculture of seven species (Silver carp, Bighead carp, Chinese bream, Grass carp, Black carp, Common carp and Crucian carp), the overall fish yield in the BFL ponds was 26.2% higher than in FPM ponds and all the species responded similarly, except for the Bighead carp that grew at the same rate on both treatments (Han Yuqin and Ding Jieyi 1983). In contrast, in the present study the Bighead carp grew faster in the effluent ponds (0.57 g/day) than in those fertilized with fresh pig manure (0.28 g/day). The Bighead carp feeds mainly on zooplankton and the population of zooplankton in the pond is dependent on the presence of phytoplankton (since zooplankton feeds on phytoplankton). Therefore, if the phytoplankton grows well, zooplankton grows well also. Thus it is to be expected that Bighead carp will grow faster in ponds loaded with effluent than in those loaded with fresh pig manure.

Nitrogen recycling

The efficiency with which nutrients are recycled in the farming system is an important indicator of sustainability. In the present study, estimates were made of the proportion of the applied fertilizer nitrogen that was recovered in the fish biomass (Table 10). For the estimation of the nitrogen content of the fish it was assumed that 20% of the live weight was protein and that 16% of the protein was in the form of nitrogen.

Table 10: Efficiency of utilization of nitrogen in the three fertilizer systems

	Effluent	**Manure**	**U-DAP**
N balance, kg/ha			
Input in fertilizer	117	119	108
Net gain in fish	48	31	40
N recovery, %	42	26	37

*N recovery = (N gain - N input)*100*

The rate of recovery of the nitrogen was highest for the effluent and lowest for the fresh pig manure. In other words, processing the pig manure through the biodigester increased the rate of utilization of the nitrogen for fish growth by 62%. The only comparable data are from the study of Kean Sophea and Preston (2001) where the effluent derived from a similar type of plastic plug-flow biodigester, also charged with pig manure, was used as fertilizer for growing water spinach planted in nutrient-poor sandy soil. The recovery of nitrogen in the water spinach biomass after a 28 day growth period with application of 140 kg N/ha was 54%. Both the water spinach and the fish are edible by people and animals, however, the market value of the protein in fish for human consumption (about Rs 15,000/kg) is at least 50% higher than the protein in the water spinach (about Rs 10,000/kg of protein) [USD 1.00 = Rs 4,000].

Conclusion

Processing pig manure in an anaerobic biodigester, before using it as fertilizer for ponds stocked with a fish polyculture, resulted in a 55% increase in net fish growth compared with direct application of the fresh manure.

Compared with the use of iso-nitrogenous amounts of a mixture of urea and di-ammonium phosphate, the net fish yield was increased by 27% in the ponds fertilized with biodigester effluent.

All of the five fish species (Tilapia, Silver carp, Bighead carp, Silver barb and Mrigal) grew faster in ponds fertilized with effluent than with manure, but the degree of response was highest for Silver Carp, Bighead carp and Tilapia and least for Mrigal.

Dissolved oxygen concentrations were significantly increased when the ponds were fertilized with effluent compared with fresh manure. Thus the principal benefit of prior anaerobic digestion of pig manure appears to be the decrease in the BOD (biological oxygen demand) in the effluent due to removal of carbon as methane in the digestion process.

The recovery of nitrogen in the fish from the nitrogen in the fertilizer was 42% for the biogester effluent, 26% for the fresh manure and 37% for the mixture of urea and di-ammonium phosphate.

Acknowledgement

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References

AOAC 1990 Official Methods of Analysis. Association of Official Analytical Chemists. 15th edition (K Helrick editor) Arlington pp 1230

Bui Xuan An, Preston T R and Dolberg F 1997 The introduction of low-cost polyethylene tube biodigesters on small scale farms in Vietnam. Livestock Research for Rural Development (9) 2: http://www.cipav.org.co/lrrd/lrrd9/2/an92.htm

Ding Jieyi and Han Yujin 1984 Comparative studies on the effects of fresh pig manure and anaerobically fermented pig manure upon fish farming, p: 288-296.

Knud-Hansen C F, McNabb C D and Bartterson T R 1991 Application of limnology for efficient nutrient utilization in tropic pond aquaculture. Verh. Internat. Verein Limnol., 24:2,541-2.543.

Le Ha Chau 1998a Biodigester effluent versus manure from pigs or cattle as fertilizer for production of cassava foliage (*Manihot esculenta*). Livestock Research for Rural Development (10) 3: http://www.cipav.org.co/lrrd/lrrd10/3/chau1.htm

Le Ha Chau 1998b Biodigester effluent versus manure, from pigs or cattle, as fertilizer for duckweed (*Lemna spp.*). Livestock Research for Rural Development (10) 3: http://www.cipav.org.co/lrrd/lrrd10/3/chau2.htm

Lin C K, Teichert-Coddington D R, Green BW and Veverica K L 1997 Fertilization regimes. In: H.S. Egna and K.L. Boyd (Editors), Dynamic of pond aquaculture. CRCP Press, Boca Raton/ New York.

Lin C K, Yang Yi, Shivappa R B and Kabir Chowhury M A 1998 Optimization of Nitrogen Fertilization

Rate in Freshwater Tilapia Production Ponds. PD/A CRSP Sixteenth Annual Technical Report, P: 49-56

Preston T R 2000 Livestock Production from Local Resources in an Integrated Farming System; a Sustainable Alternative for the Benefit of Small Scale Farmers and the Environment. Workshop-seminar "Making better use of local feed resources" January, 2000. SAREC-UAF (Editors: T R Preston and R B Ogle). http://www.forum.org.kh/~wwwuta/sarpro/preston.htm

Swingle H S 1969 Methods of analysis for waters, organic matter and pond bottom soils used in fisheries research. Auburn, AL: Auburn University.

Undersander D, Mertens D R and Thiex N 1993 Forage analysis procedures. pp 154 National Forage Testing Association. Omaha: pp154

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