COMPARISON OF NITROGEN AND PHOSPHORUS DYNAMICS OF SWINE LAGOON EFFLUENT AND FERTILIZER BASED FORAGE SYSTEMS

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INTRODUCTION

Land application of animal wastes and recycling nutrients through the soil-plant system has been a commonly accepted method of disposal. With the current interest in sustainable agriculture, recycling of nutrients such as N and P through land application of animal waste is a viable alternative to conventional fertilizer. Depending upon conventional fertilizer costs, animal wastes can be used as a source of plant nutrients (Wilkenson 1979). Forage crops have been shown to respond favorably to swine lagoon effluent. In research conducted by Westerman et al. (1983) to determine the effects of swine effluent on tall fescue yield, it was found that anaerobic swine effluent substantially increased tall fescue yield over inorganic fertilizer. According to Westerman et al. (1983), 'Coastal' bermuda grass responded favorably to anaerobic swine effluent. Anaerobic swine effluent at rates of 335, 670, and 1370 kg N/ha resulted in respective yields of 10750, 14230, and 15810 kg/ha. In another study utilizing 'Coastal' bermuda grass, Burns et al. (1985) found that anaerobic swine effluent resulted in positive uptake of N and P with increased application rate. Swine lagoon effluent has been shown to increase the fertility status of soils. King et al. (1990) observed that swine lagoon application equivalent to 0, 111, 221, and 442 kg P/ha increased levels of extractable soil P 85, 230, 320, and 450 mg/kg, respectively. Elevated nitrate-N content in the soil profile can occur from swine lagoon effluent as well. According to King et al. (1990), in research involving three rates of swine effluent equivalent to 335, 670, and 1340 kg N/ha, there was a significant increase in nitrate-N below 60 cm with the concentration reaching a peak of 35 mg/kg at 90 cm. The check, low, and medium rates of application never exceeded 5 mg/kg at any depth. In research conducted by Sutton et al. (1978), downward movement of nitrate-N and P in the soil profile of plots receiving swine waste and fertilizer was studied. It was observed that accumulation of P occurred in the soil surface. There was no evidence of P leaching in the soil and, in most cases, available P concentrations in the soil reflected the amount of P in the swine waste applied to the soil. The greatest movement of nitrate-N as induced by the highest nitrate-N concentration was with inorganic fertilizer. Since N and P in lagoon effluent are of prime importance agronomically and environmentally, the proper management of swine lagoon effluent must be determined to improve crop production and to prevent degradation of water quality. Given this background, the objective of this study was to determine the effects of swine lagoon effluent rates on N and P uptake by forage grasses and movement of these nutrient in the soil profile relative to inorganic fertilizer.

MATERIALS AND METHODS

The experiment was conducted in 1994 at a commercial hog facility located near Brooksville, Mississippi, on two different soil types which have been previously described by Adeli et al. (1995). In 1995, the research was continued at the same sites with a few changes. 'Alicia' bermuda grass sprigs were planted on the Vaiden site 6 June 1995. The bermuda grass sprigs were irrigated with fresh water until established. A randomized complete block design with seven treatments and four replications was used on the Vaiden site. In 1995, treatments applied to a Vaiden clay soil (very fine, montmorillonitic, thermic Aquic Dystrudert) consisted of an irrigated check (fresh water), swine lagoon effluent applied at rates equivalent to approximately 115 kg N - 17 kg P, 224 kg N - 29 kg P, and 365 kg N-46 kg P/ha or 2.5, 5.0, and 7.5 ha-cm of irrigation. Additional plots in each replication received commercial fertilizer at rates of 112 kg N-14 kg P, 224 kg N-28 kg P, and 336 kg N-42 kg P/ha. Treatments applied to an Okolona clay soil (fine, montmorillonitic, thermic Typic Chromuderts) consisted of an irrigated check (fresh water), swine lagoon effluent applied at rates equivalent to approximately 246 kg N-30 kg P, 453 kg N-60 kg P, and 665 kg N-90 kg P/ha or 5.0, 10.0, and 15.0 ha-cm of irrigation and commercial fertilizer was applied at rates of 224 kg N-28 kg P, 448 kg N-56 kg P, and 672 kg N-82 kg P/ha for comparison. In 1995, the first irrigation with swine lagoon effluent was applied to the Okolona site on 25 May 1995, in which 2.5 cm swine lagoon effluent was applied. At each irrigation, swine effluent samples were obtained for analysis. Electrical conductivity and pH were determined immediately, then samples were acidified with concentrated H_2SO4 (2ml/L) and stored at -4°C until analyzed. Analysis of effluent included a total Kjeldahl N digestion (TKN) and colorimetric determination of ammonium using indophenol blue as described by Cataldo et al. (1974). Total inorganic N (ammonium and nitrate-N) was determined via steam distillation using a method described by Bermner and Keeney (1965). Total and ortho-P was determined using a colorimetric procedure developed by Murphy and Riley (1962) which utilize ascorbic acid as the reducing agent. Effluent samples were centrifuged prior to determination of Ortho-P. Forage harvests were obtained at an appropriate growth stage and dry matter yield was determined. Forage harvests were weighed and subsampled for dry matter determination and laboratory analysis. Samples were dried at 65°C in a forced air oven for dry matter determination. Dried forage samples were ground in a Wiley mill to pass a 1-mm screen and stored in sealed plastic bags until analyzed. Samples were dry ashed and diluted to a final concentration of 0.19 N HCl. Phosphorous were determined using the same colorimetric method as previously mentioned. Nitrogen in plant tissue was measured using a dry combustion technique. Soil samples were taken randomly from each plot at depths 0 to 5-, 5 to 15-, and 15 to 30-cm at the Vaiden site and 0 to 5-, 5 to 15-, 15 to 30-, and 30 to 60-cm at the Okolona site to characterize the N and P levels. Soil samples were air-dried for 24 h on greenhouse benches. After air-drying, soil samples were ground to pass a 2-mm sieve and stored for later analysis. Extractable P was determined via the Mississippi Soil Test Method (Lancaster 1970). Total inorganic N was determined by steam distillation (Bremner and Keeney 1965) and NH_4^+-N was determined using an indophenol blue method (Cataldo et al. 1974). Water extractable P was determined using a slightly modified procedure described by Olsen and Sommers (1982). An analysis of variance was performed by using SAS statistical software (SAS Institute 1985). Mean separations between treatments were performed using Least Significant Difference. All statistical results are reported at the 0.05 probability level.

RESULTS AND DISCUSSION

Analysis of Anaerobic Swine Effluent

Swine lagoon effluent analysis for each treatment and soil type in 1994 and 1995 are shown in Table 1. All pH measurements were found to be near 8.0 in 1994 and 1995. Total N values include ammonium-N, nitrate-N, and organic N were greater in 1995 than in 1994. The majority of the N in the effluent existed as ammonium-N with minimal nitrate-N, reflecting the anaerobic nature of the decomposition of swine waste in the lagoon. Effluent analysis in 1995 indicated that electrical conductivity was greater than in 1994. This could be related to the higher concentration of total N in the swine lagoon effluent in 1995. Also, total P applied in 1995 was greater than in 1994. Similar to N, most of the P existed as inorganic ortho-P indicating that swine lagoon effluent is chemically similar to commercial fertilizer.

Crop Response

Okolona - Dry matter yield was increased both years by swine lagoon effluent and inorganic fertilizer application compared to the check treatment (Table 2). Dry matter yield from plots receiving medium (200 kg N-26 kg P/ha) and high (385 kg N-39 kg P/ha) rates of swine lagoon effluent were not different ($P>0.05$) from each other, but these rates increased dry matter yield more than the low rate. In 1995, dry matter yield was significantly increased with increasing swine lagoon effluent application rates ($P<0.05$).

Vaiden - Application rates on the Vaiden soil were the same both years. Therefore, two-year average values were used for interpretation. The two-year average for dry matter yield is shown in Table 3. Swine lagoon effluent and inorganic fertilizer application rates increased dry matter yield compared to the check plot. Dry matter yield was significantly increased with increasing application rates of swine lagoon effluent. However, yield from plots receiving medium (224 kg N-28 kg P/ha) and high (336 kg N-42 kg P/ha) inorganic fertilizer rates were not significantly different from each other, but these rates increased dry matter yields more than low rate.

N and P Uptake and Recovery

Okolona - Removal of N by johnson grass was increased ($P<0.05$) with increasing swine lagoon effluent and inorganic fertilizer application rates both years. Except in 1995 when N uptake from plots receiving medium (446 kg N-56 kg P/ha) and high (672 kg N-84 kg P/ha) inorganic fertilizer rates were not different ($P>0.05$) from each other, but these rates increased N uptake more than the low rate (Table 2). The major factor influencing removal of N was dry matter yield. Consequently, the relationship between N uptake and applied N has the same form as does dry matter. Phosphorous uptake was increased by swine lagoon effluent and inorganic fertilizer application when compared to the check plots in 1994 and 1995. Removal of P from plots receiving medium and high swine lagoon effluent application rates were not significantly different from each other, but these rates increased P uptake more than the low rate, but only in 1994. Swine lagoon effluent and inorganic fertilizer application rates did not significantly affect N and P recovery by the grass on the Okolona soil in 1994. However, in 1995 the efficiency of N and P recovery was significantly decreased with increasing rates of swine lagoon effluent and inorganic fertilizer (Table 4). Medium and high swine lagoon effluent and inorganic fertilizer rates applied resulted in proportionately greater quantities of N and P that were not recovered. Poor recovery of N at high swine effluent and fertilizer rates could be caused by greater losses of N (Meek et al. 1981).

Vaiden - The average annual quantities of N and P removed in the forage grass are shown in Table 3. Removal of N and P in the grass increased with swine lagoon effluent application rates ($P<0.05$). Nitrogen uptake from plots receiving medium and high inorganic fertilizer rates were not different ($P>0.05$) from each other, but these rates increased ($P<0.05$) N uptake more than the low rate. The percentage of N and P recovery decreased with increasing swine lagoon effluent and inorganic fertilizer application rates ($P<0.05$). Because of poor recovery at high swine lagoon effluent and inorganic fertilizer rates, large quantities of N and P remained in the soil environment. This indicates a potential problem with excess soil accumulation of P and movement of nitrate-N to ground water.

Soil Nitrate-N and Phosphorous

Okolona - There was no significant treatment effect ($P>0.05$) in 1994 of swine lagoon effluent or inorganic fertilizer application on nitrate-N concentrations at all depths (Table 7). The only significant ($P<0.05$) effect when compared to the zero check was the high rate of inorganic fertilizer (336 kg N/ha) application. Nitrate-N concentrations were greatest in the 0 to 5 cm depth of the Okolona soil due to the application of inorganic fertilizer and swine lagoon effluent, but the differences were not significant when compared to the zero check. At the end of the second year, nitrate-N concentration increased with increased swine lagoon effluent applications, but the only significant effect when compared to zero check was the highest rate of swine lagoon effluent application at all depths. The highest rate of inorganic fertilizer application significantly increased ($P<0.05$) soil nitrate-N when compared to the zero check and swine lagoon effluent application treatments (Table 8). Generally, soil nitrate increased with increasing rates of swine lagoon effluent and inorganic fertilizer, but little accumulations of nitrate were observed. Only with the highest rate (672 kg N/ha) of inorganic fertilizer and swine lagoon effluent (665 kg N/ha) was there a significant accumulation of nitrate-N compared to the other application rates. Even though swine lagoon effluent provided approximately the same total amount of N as inorganic fertilizer, the greatest accumulation of nitrate-N in the soil profile as indicated by the highest nitrate-N concentration was with inorganic fertilizer. This could be related to greater leaching of nitrate-N with swine lagoon application due to the greater quantity of irrigation water applied and the resulting greater soil moisture content. Available P increased ($P<0.05$) in the 0 to 5 cm depth of the Okolona soil due to swine lagoon effluent and fertilizer applications compared to the zero check in 1994 (Tables 7 and 8). However, the only significant effect was an increase in available P from the highest (42 kg P/ha) rate of swine lagoon effluent and fertilizer application in 1994. In 1995, available P concentration increased ($P<0.05$) with increasing swine lagoon effluent application rate. For the 0 to 5-cm soil depth swine lagoon effluent application increased available soil P more than equivalent inorganic fertilizer application rates. Results from our study are in agreement with findings of Booram et al. (1974) who reported that the magnitude of P accumulation in soils has been shown to increase with increasing rates of swine waste applications. Swine lagoon effluent and fertilizer rates did not increase available P in the 5 to 15 - and 15 to 30-cm depths. Phosphorus applied to the soil surface in no-tillage cropping systems generally remains in the soil surface (Eckert and Johnson 1985).

Vaiden - Two-year average soil nitrate concentration and available P values are shown in Table 6. Nitrate-N concentration increased the greatest in the 0 to 5 cm soil depth with swine lagoon effluent and inorganic fertilizer, but the only significant effect ($P<0.05$) for soil nitrate levels was between the zero check and the highest rate of inorganic fertilizer application. Available P concentration increased ($P<0.05$) in the 0 to 5 cm depth due to swine lagoon effluent and fertilizer. Swine lagoon effluent and fertilizer rates did not significantly increase extractable P in the 5 to 15 - and 15 to 30-cm soil depths. This is likely related to the high clay content of this soil which results in high adsorption or retention of applied P to the soil (Reddy et al. 1980). In all cases for both soils, increasing P concentrations in the surface soil (0 to 5 cm) could increase the potential for transport of P in storm runoff. Accumulation of P at the soil surface raises concerns that P may be transported into surface-water in runoff events. The highest potential for surface-water pollution would occur if erosion was significant. Application rates near the medium level of 56 kg P/ha used on the Okolona soil could prevent excess accumulation of N and P in the soil profile and at the soil surface. Desorbed P from consecutive four 1-hour extractions was measured only for the 0 to 5 cm surface soil. Total phosphorous desorption increased with increasing swine lagoon effluent and fertilizer application rates. At the highest rate of swine lagoon effluent application 0.86 and 0.14 μg P/g of soil were desorbed from the Okolona and Vaiden soils, respectively. In both soils desorbed P was linearly increased ($P<0.05$) with increasing soil test P level (data not shown). Results of our experiment were in agreement with the findings of Tom and Logan (1980), who found that P desorption significantly increased with increasing soil test P levels. An increase in desorbable P indicates an increasing potential for higher levels of soluble P in runoff as extractable P levels continue to increase with increasing swine lagoon effluent and inorganic fertilizer application.

CONCLUSION

Because of the importance of N and P contained in swine lagoon effluent, the dynamics of these nutrients in a soil-plant system were evaluated agronomically and environmentally. Swine lagoon analysis results showed that most of the N and P in the swine lagoon effluent existed as inorganic forms indicating that swine effluent was chemically similar to commercial fertilizer. Dry matter yield increased with increasing swine lagoon effluent and inorganic fertilizer application rates, but there was little advantage in dry matter production from applying swine lagoon effluent and inorganic fertilizer above the medium rates. Nitrogen removal followed a similar pattern as dry matter production. It was concluded that forage crops are capable of utilizing plant nutrients contained in animal waste and would help to reduce nutrient accumulation within the soil, therefore limiting the risk of environmental contamination. The efficiency of N and P recovery was significantly decreased with increasing rates of swine lagoon effluent and inorganic fertilizer application in 1995. Poor recovery of N at high swine effluent and fertilizer application rates was evident. Since only a small portion of the supplied P is removed by the crops, it is apparent that soil reserves of P will be increased by high rates. Thus, there is a potential problem with excess soil accumulation of P and movement of N to ground water at high rates. Swine lagoon effluent application rates provided approximately the same amounts of N and P for the soil as did inorganic fertilizer rates. Therefore, the lower accumulation of nitrate from the high rate of swine lagoon effluent application could be related to greater leaching or denitrification. Swine lagoon effluent and inorganic fertilizer significantly increased soil P concentration in the 0 to 5 cm depth in 1994 and 1995. Given the low mobility of P in most soils, the shallow surface soil may become highly enriched in P relative to the rest part of the soil profile increasing the potential for P in runoff. Therefore, application rates not exceeding 448 kg N-56 kg P/ha would be most acceptable environmentally at this point in time. Phosphorus desorption significantly increased with increased soil test P levels. This relationship indicates the potential for higher levels of soluble P in runoff as soil test P levels increase.

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REFERENCES

Adeli A., J.J. Varco, and T. Burcham. 1995. Swine lagoon effluent and N-P-K fertilizer effects on yield, nutrient removal, and residual soil levels of N and P. P. In Proceedings of the 25th Mississippi Water Resources Conference, April 11-12, 1995, edited by B. Jean Daniel, 213-228. Water Resources Research Institute: Mississippi State University.

Bermner, J.M., and D.R. Keeney. 1966. Steam distillation methods for determination of ammonia, nitrate and nitrite. Anal. Chim. Acta. 27:31-36.

Booram C.V., T.E. Longnachan, and G.K. Loelliker. 1974. Effects of sprinkler application of lagoon effluent on corn and grain sorghum. P. 493-502. In Proc. Agricultural Waste Management. Cornell University, Rochester, N.Y. 25 March 1974.

Cataldo, D.A., L.E. Schrader, and V.L. Youngs. 1974. Analysis by digestion and colorimetric assay of total nitrogen in plant tissue high in nitrate. Crop Science 14:854-856.

Eckert, D.J., and J.W. Johnson. 1985. Phosphorus fertilization in no-tillage corn production. Agron. J. 77:789-792.

Lancaster, J.D. 1970. Determination of available P and K in soils. Miss. Agric. Forst. Exp. Sta. unpublished mimeographical material.

Meek, B.L., L. Graham, and T. Donovan. 1982. Long-term effects of manure on soil nitrogen, phosphorus, potassium, sodium, organic matter, and water infiltration rate. Soil Sci. Soc. Am. J. , 46:1014-1019.

Miner J.R., G.G. Anthony, and E.P. Taiganids. 1983. Chemical treatment on anaerobic swine lagoon effect and content. Transactions of the ASAE p. 1177-1180.

Murphy, J., and J.P. Riley. 1962. A modified single solution method for determination of phosphate in normal water. Anal. Chim. Acta. 27:31-36.

Olsen, S.R., and L.E. Sommer. 1982. Phosphorus. In Methods of soil analysis edited by A.L. Page, R.H. Miller, and D.R. Keeney, part 2. ASA Madison WI.

Reddy, K.R., M.R. Overcash, and P.W. Westerman. 1980. Phosphorus sorption-desorption characteristics of two soils used for disposal of animal waste. J. Environ. Qual. 9:86-92.

Tom, O. O, and T.J. Logan. 1980. Phosphorus desorption from soils and sediment with varying levels of extractable phosphate. J. Environ. Qual. 9:526-531.

Westerman, P. W., J. C. Burns, and L. D. Kings. 1983. Swine lagoon effluent applied to 'Coastal' bermudagrass, EPA-600152-83-078.

Wilkenson, S.R. 1979. Plant nutrient and economic value of animal wastes. J. Anim. Sci. 48:121-123.

Table 1. Anerobic swine lagoon effluent analysis for each irrigation in 1994 and 1995.

Irrigation Rate	Soil Type	pH	EC	TKN	NH4^{+}	NO3	TOT-P	Ortho-P
cm			mmho/cm	----------	----------	ug/ml	----------	----------
					1994			
2.5	Vaiden	8.08	3.72	398	351	5	50	43
5		7.77	3.73	369	292	7	65	57
7.5		7.82	3.4	364	303	11	41	36
2.5	Okolona	8.11	3.49	389	343	6	45	38
5		7.81	3.74	367	296	8	54	46
7.5		7.82	3.40	364	303	11	41	36
					1995			
2.5	Vaiden	7.61	3.9	454	354	32	68	59
5		7.72	4.2	424	360	34	61	53
7.5		7.83	4.3	411	353	15	55	50
5	Okolona	7.7	4.5	484	354	43	60	47
10		7.74	4.1	408	317	35	60	52
15		7.77	4.2	416	379	14	60	53

Table 2. Dry matter yield and total nitrogen and phosphorus removed by forage grown on an Okolona soil as influenced by fertilizer and effluent application rates in 1994 and 1995.

1994				1995			
Treatment N-P	Yield	N	P	Treatment N-P	Yield	N	P
	Kg/ha				Kg/ha		
Fertilizer (kg/ha)				Fertilizer (kg/ha)			
0-0	2169	28.0	4.7	0-0	5219	49.5	8.9
112-14	3588	49.0	6.2	224-28	8536	149.4	18.3
224-28	3795	72.2	6.8	448-56	10663	236.1	22.5
336-42	4021	93.1	7.8	672-84	10394	240.3	23.2
Effluent (kg/ha)							
100-12	3204	44.0	6.0	246-30	8407	145.5	21.9
200-26	4746	72.6	3.4	453-60	10679	200.0	23.9
285-39	4844	93.9	9.5	665-90	12584	244.6	25.8
CV%	8.3	14.9	12.6	CV%	13.9	14.1	14.8
LSD (0.05)	463	14.3	1.3	LSD (0.05)	1892	37.7	4.5

Table 3. The average of total dry matter yield, nitrogen and phosphorus uptake by forage grown on a Vaiden soil as influenced by fertilizer and swine lagoon effluent application rates for two years.

Treatment N-P	Yield	N	P
Fertilizer			
	Kg/ha		
0-0	2732	27.2	5.1
112-14	4185	72.8	7.5
224-28	4799	102.3	7.9
336-42	4942	109.8	9.00
Effluent (kg/ha)			
108-15	4621	71.6	9.5
213-28	5314	95.9	10.8
325-43	5896	114.5	12.4
CV%	7.0	11.3	8.8
LSD (0.05)	483	14.0	1.14

Table 4. Effects of swine lagoon effluent and fertilizer rates on nitrogen and phosphorous recovery on an Okolona soil in 1994 and 1995.

1994			1995		
Treatment N-P	N recovery	P recovery	Treatment N-P	N recovery	P recovery
Fertilizer (kg/ha)	%		Fertilizer (kg/ha)	%	
112-14	18.8	11	224-28	44.5	33.8
224-28	20.0	9	448-56	41.5	24.5
336-56	19.3	7.3	672-84	28.0	15.8
Effluent (kg/ha)			Effluent (kg/ha)		
100-12	15.8	14.5	246-30	39.3	43.8
200-29	22.3	14.0	453-60	33.3	26.0
285-39	23.3	12.0	665-90	29.3	20.0
CV%	25.0	37.5	CV%	18.8	25.6
LSD (0.05)	NS	NS	LSD (0.05)	10.2	10.5

NS - not significant

Table 5. Effects of swine lagoon effluent and fertilizer rates on nitrogen and phosphorous recovery on a Vaiden soil (two year average).

Treatment N-P	N Recovery	P Recovery
Fertilizer (kg/ha)	%	
0-0		
112-14	41	17
224-28	34	10.0
336-42	25	9.2
Effluent (kg/ha)		
108-15	39	32
213-28	31	20
325-43	27	16
CV%	15	27
LSD (0.05)	9.1	7.2

Table 6. Soil nitrate and phosphorus concentration as influenced by and swine lagoon effluent and fertilizer application rates on a Vaiden soil (two year average).

	Soil depth, cm					
Treatment N-P	0 to 5	5 to 15	15 to 30	0 to 5	5 to 15	15 to 30
Fertilizer (kg/ha)		μg P/g			μg NO_3^-/g	
0-0	9.2	4.0	0.93	0.94	0.50	0.32
112-14	12.1	4.8	1.08	1.40	0.52	0.52
224-28	17.2	4.6	0.88	3.00	0.61	0.51
336-42	21.4	4.7	0.93	12.83	10.98	6.64
Effluent (Kg/ha)						
108-15	12.1	4.6	1.0	1.02	0.63	0.36
213-28	17.3	4.7	1.05	1.19	0.58	0.25
325-43	20.2	4.8	1.20	1.60	.093	0.76
CV%	7.91	15.9	18.5	28.9	53.4	52.8
LSD (0.05)	1.8	NS	NS	1.35	1.67	1.05

NS - not significant

Table 7. Soil nitrate and phosphorous concentration as influenced by fertilizer and swine lagoon effluent application rates on an Okolona soil in 1994.

	Soil depth, cm					
Treatment N-P	0 to 5	5 to 15	15 to 30	0 to 5	5 to 15	15 to 30
Fertilizer (kg/ha)		μg P/g			μg NO_3^-/g	
0-0	14.3	6.5	4.2	1.38	1.03	.99
112-14	15.2	6.8	4.0	1.94	1.11	1.03
224-28	16.6	6.9	4.0	2.16	1.19	1.10
336-42	22.1	7.9	4.0	2.71	2.37	1.83
Effluent (kg/ha)						
100-12	16.5	8.3	3.8	1.57	1.08	0.71
200-26	18.6	7.8	4.7	2.24	1.17	0.85
285-39	23.1	7.9	4.5	2.44	1.44	0.95
CV%	13.3	17.8	18.4	30.6	10.4	40.8
LSD (0.05)	3.6	NS	NS	NS	0.75	0.64

NS - not significant

Table 8. Soil nitrate and phosphorous concentration as influenced by fertilizer and swine lagoon effluent application rates on an Okolona soil in 1995.

	Soil depth, cm							
Treatment N-P	0 to 5	5 to 15	15 to 30	30 to 60	0 to 5	5 to 15	15 to 30	30 to 60
Fertilizer (kg/ha)		μg P/g				μg NO_3^-/g		
0-0	11.6	6.0	3.5	3.5	1.55	1.24	0.28	0.98
224-28	16.8	6.3	3.1	3.1	2.53	1.04	0.33	1.4
448-56	21.4	7.4	3.3	4.2	5.78	5.4	14.03	7.4
672-84	31.5	8.1	3.9	5.8	17.56	32.9	51.78	34.2
Effluent (kg/ha)								
246-30	20.4	6.9	3.0	4.1	2.88	2.87	0.38	.75
453-60	27.2	7.1	3.7	4.3	3.10	2.34	0.90	1.95
665-90	35.3	9.0	4.2	6.2	5.9	9.0	6.08	12.50
CV%	16.2	26.3	19.9	36.6	34.7	39.9	50.3	23.8
LSD (0.05)	5.6	NS	NS	NS	2.8	4.6	7.9	4.9

NS - not significant