NITROGEN MINERALIZED FROM MANURE AMENDED SOILS

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ABSTRACT

A practical remedy for the disposal of feedlot manures and other animal wastes is through recycling via cropland application. Knowing the amount of manure that is safe and cost-effective to apply requires a knowledge of the rate and amount of nutrient release from the manure. The objective of this research is to quantify manure chemical and physical characteristics and relate those measurements to the rate and amount of N mineralized (N_{min}) from the manures. Eighteen select manures representing 6 animal species were analyzed for total nitrogen (N) and carbon (C), fiber and inorganic N. Two soils, a Weld silt loam and a Valent sand were amended with the equivalent dry weight of 10 ton/acre of animal manure and incubated for 132 days using a method modified from Stanford and Smith (1972). Manure N_{min} curves were developed and the total N_{min} and the % of the N_{min} are reported. The percent N_{min} ranged from 0.0 to 70.4 under near optimal laboratory conditions. The net N_{min} of solid chicken manure was 70.4 % in the first 132 days of the incubation. Whereas, sheep solid manure measured net N_{min} was 1.3% in the same period.

INTRODUCTION

Concentrated animal production units containing 50, 000 head or greater are now common. Animal waste disposal and potential water contamination are problems associated with these facilities. A reasonable solution is to recycle animal wastes through application to crop-land. Manure application to cropland has well-known, established benefits such as increasing soil organic matter, improving soil structure, water holding capacity and increasing soil nutrient availability(Tiarks et al. 1974). However, water quality issues are relevant due to excessive application rates, mismanagement, poor timing or combinations of the above. Excessive nitrate buildup in groundwater throughout the world is well documented.

In Colorado, a survey has shown that the highest groundwater nitrate concentrations are found in areas near feedlots (Dubois 1994). Farmers may apply excessive manure amounts due to the economics of hauling manure longer distances from feedlots and the insufficient crediting of nutrients from manures (GPAC 1995). Centuries of experience with manures as crop nutrient sources and extensive literature concerned with nitrate accumulation from excessive manure application have not lead to rational manure management practice. Best Management Practices exist but do not take into account the unique conditions of the arid west central Great Plains or the variability in manure's chemistry.

The objective of this research is to quantify manure chemical and physical characteristics and relate those measurements to the rate and amount of N mineralized from the manures. Knowing various manures' mineralization rates and total mineralization potentials, under optimal conditions, is critical for development of reliable BMP's.

MATERIAL AND METHODS

Eighteen manure samples were selected from a group of 137 for laboratory incubation. Sample selection criteria was based on how the samples varied in total N and C, soluble N and C, and ın Soest fiber analysis (Goring and Van Soest 1970) (Table 1). That is, samples were selected to ıtain a wide range in physical and chemical characteristics. Manures were oven dried at 60°C and 23 g of each manure was mixed with 15 g of either a weld silt loam or a Valent sand. To each soil ınure mixture 15 g of acid-washed sand was mixed and then packed into 60 mL leach tubes using e method of Vigil and Kissel (1995). The 0.23 g of manure, mixed, with 15.0 g of soil, is equivalent 10 dry tons of animal manure/acre assuming a bulk density of 1.45 g/cm^3 and a 10 cm mixing pth. Manure amended soils were incubated at a constant temperature of 30°C and near a water-led-pore space of 55%.

Leach tubes were periodically leached with 0.01M $CaCl_2$ and the extract was analyzed for trate-N (NO_3-N) and ammonium-N (NH_4-N) using a Lachat autoanalyzer. The total N accumulated ver a 132 day incubation was summed and graphed. Both N_{min} in unamended soil and manure nended soil was measured. Estimated net N_{min} was calculated by subtracting the total amount of N_{min} unamended soil from the total N_{min} in amended soil. The fraction of N recovered was calculated ing:

$$\text{Fraction recovered} = (\text{net } N_{min} / \text{N applied}) \times 100 \qquad [1]$$

here the N applied is the concentration of N in the manure and net N_{min} is as described above.

RESULTS AND DISCUSSION

The samples incubated varied from 6.7 to 18.9 in C/N ratio (table 1). First-order kinetics are parent from the 4 samples graphed in Fig. 1. The C/N ratios in these graphs range from 6.7 to 18.1, ose to the extremes of our 18 samples. The figure shows net immobilization occurred in the beef d two of the chicken samples during the first 42 days of the incubation. The chicken sample with C/N ratio of 6.7, the narrowest of the four, did not show net immobilization. In general, the wider /N ratios show less N_{min} than the narrower C/N ratios. This is consistent with common thought with spect to C/N ratio. However, we are continuing to collect data for these samples and data, not own here, indicate that C/N values will only partially explain mineralization rates. Fiber and soluble contents may be necessary to develop reliable, predictive, N_{min} rates for these manures. Table 2 dicates that 13 of our 18 samples showed less than 50% of the N applied as manure was recovered fter 132 days of incubation under optimum laboratory conditions. Only chicken samples and one airy sample showed greater than 50% recovery. In the field, in arid cropping systems such as found Colorado, one would not expect to obtain similar values until at least one year after application. his means that the standard rule of thumb of 50% for recoverable N in the first year is probably high r the arid Great Plains. Additionally, the first order relationship demonstrated in Fig. 1 indicates that the majority of our samples our recoverable fraction will remain under 50% even under longer cubations than shown here.

Chicken manures, (Fig.1) have high initial and total N_{min}. amounts. The graph of a Chicken olid sample with a C/N of 6.7 shows nearly 550 mg N/kg of soil that is recovered after 132 days of cubation. This translates to roughly 640 lbs of recoverable N per acre for every 10 tons (dry-weight asis) of this chicken manure applied (This assumes a soil bulk density of 1.3 g/cm^3 and an corporation depth of 10cm). To obtain a rate of, for example, 200 pounds of N per acre within the rst year from this manure, an application of less than 3 tons per acre would be sufficient.

Table 1. Chemical and physical characteristics of manure samples used in laboratory incubations.

Species/type	C/N	Total N	ADF†	NDF‡	NH_4-N	NO_3-N
		%			mg/kg	
Turkey compost	7.3	3.57	60.4	62.2	61.0	7.9
Horse puggy	18.9	0.59	48.9	48.1	3.7	.2
Beef dry solid	13.1	1.01	79.8	84.7	6.6	0.1
Hog moist solid	11.7	2.72	38.4	55.5	152.4	0.1
Beef Solid	13.8	2.18	44.3	69.8	37.7	0.1
Beef Solid	14.4	1.88	60.0	67.0	15.7	0.1
Chicken moist solid	8.0	2.64	47.8	57.0	103.5	0.3
Chicken moist solid	6.7	5.02	16.7	35.8	161.0	0.1
Beef moist solid	12.4	2.34	57.3	57.8	5.3	9.6
Dairy moist solid	14.8	1.69	64.8	79.0	47.2	0.2
Dairy compost	14.4	1.11	74.3	66.5	8.5	5.2
Chicken moist solid	10.3	2.28	32.7	41.3	110.9	0.3
Chicken moist solid	5.8	5.44	22.5	31.4	73.3	0.1
Dairy dry solid	12.6	0.90	83.0	84.5	8.6	1.6
Sheep moist solid	11.6	1.87	63.2	60.9	26.0	5.8
Chicken moist solid	18.1.	1.36	17.0	31.7	196.2	0.1
Chicken wet slurry	12.6	1.16	40.6	52.6	91.5	0.2
Dairy moist solid	13.6	0.73	83.0	79.3	11.7	0.1

† ADF is the acid detergent fiber.
‡ NDF is the neutral detergent fiber.

Fig.1 shows representative curves for manure N_{min}. However, representing the rest of our data is not as simple or clear. For example, our beef solid shows a 0% recovered fraction. This number indicates that we may have had anaerobic conditions in this tube and may also have had anaerobic conditions in our hog sample tubes as well. Additionally, we do not see clear first-order kinetics in graphs of some of the other samples. Further analysis is required in order to explain some of our sample results showing different kinetics than we expected.

CONCLUSIONS

Potentially mineralizable N in 72% of the manure samples tested, and in all species other than chicken and one dairy sample, was less than 50% after 132 days of incubation under optimal laboratory

Table 2. N mineralization of manure amended soils.

Species/type		soils			
	Manure C/N	Manured Weld silt loam		Manured Valent sand	
		Total †	recovered‡ fraction	Total †	recovered‡ fraction
		mg/kg	%		
Turkey compost	7.3	195.9	21.7	107.1	13.4
Horse wet	18.9	104.0	29.5	73.4	44.0
Beef dry solid	13.1	104.0	17.2	64.2	19.8
Hog moist solid	11.7	174.3	23.2	36.7	0.8
Beef solid	13.8	204.2	38.0	98.4	19.4
Beef solid	14.4	114.3	12.8	33.3	0.0
Chicken moist solid	8.0	362.1	70.4	199.6	41.0
Chicken moist solid	6.7	547.2	61.0	292.3	33.6
Beef moist solid	12.4	149.4	20.1	87.1	10.4
Dairy moist solid	14.8	172.1	36.6	91.2	22.3
Dairy compost	14.4	140.6	37.2	77.4	25.8
Chicken moist solid	10.3	271.4	55.5	168.6	38.6
Chicken moist solid	5.8	451.0	44.8	123.1	10.7
Dairy dry solid	12.6	143.0	47.6	99.1	47.5
Sheep moist solid	11.6	102.7	8.9	20.1	1.3
Chicken moist solid	18.1	204.0	12.2	102.6	33.1
Chicken wet slurry	12.6	195.1	66.2	96.2	35.2
Dairy moist solid	13.6	148.2	63.3	108.1	66.6

† Total is the total N mineralized from the manure amended soil.
‡ The fraction recovered (expressed as a percentage) is the estimated net N mineralized (total amount of N mineralized in amended soil - the amount of N mineralized in unamended soil) divided by the amount of N applied as manure.

conditions. As a first cut, this data can be used to estimate reasonable manure application rates for the field. For example a chicken manure sample with a C:N of 6.7 shows nearly 600 mg N/kg of soil that is recovered after 132 days of incubation. This translates to roughly 700 lbs of recoverable N per acre for every 10 tons (dry-weight basis). This would be an extremely high rate of application so, with this sample, an application rate of <3 tons is more reasonable.

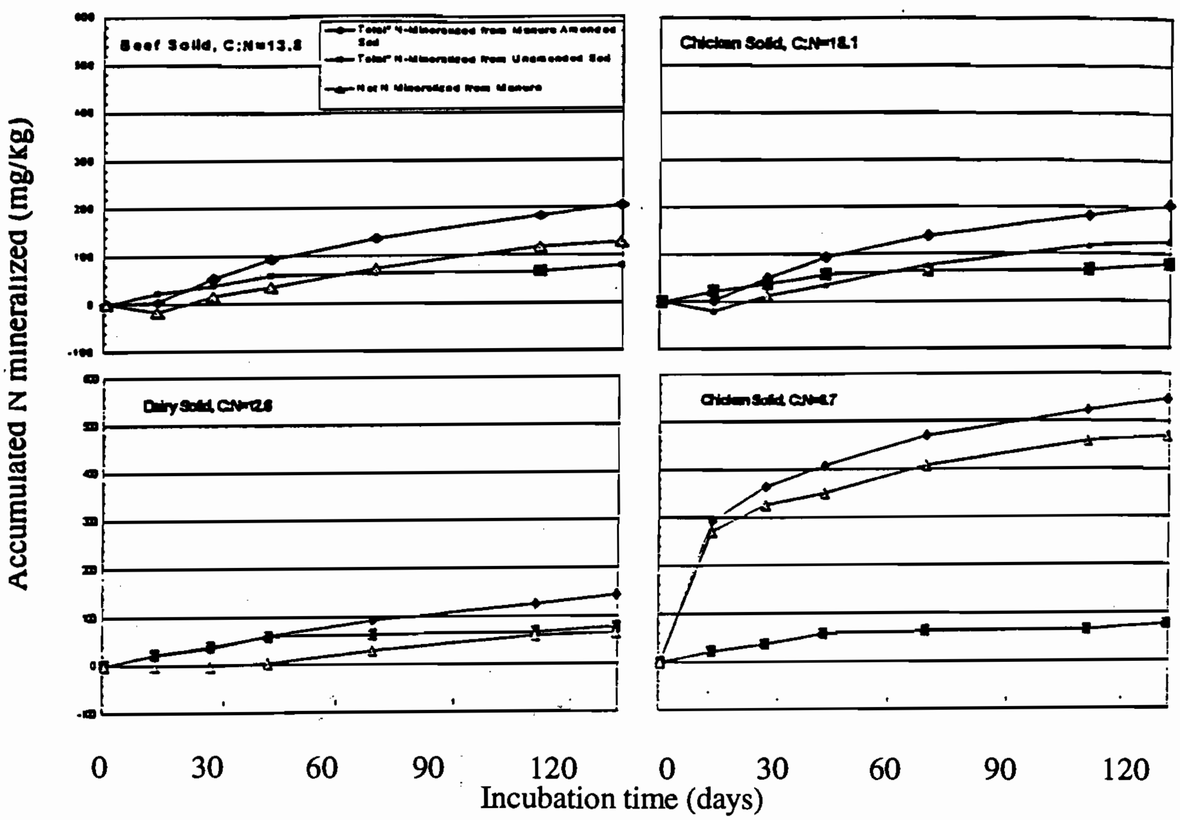

Fig 1. Accumulated N mineralized for select manures amended to Weld silt loam.

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