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NITROGEN RELEASE FROM BIOSOLIDS APPLIED TO SANDY SOIL AMENDED WITH LIME

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ABSTRACT

Most bahiagrass pastures in Florida are nutrient deficient; however, ranchers have been reducing fertilizer application due to the low cattle prices. Pelletized biosolids applied to bahiagrass pastures on an acid sandy soil increased forage yield and quality linearly with rates up to 17.6 Mg/ha and between 50 to 80% of the N was made available within the first year of application. Soil pH may have a pronounced effect on mineralization from biosolids, though. The objective of this laboratory study was to investigate the effects of variable soil pH attained by liming of an acid sandy soil, on the mineralization of N from pelletized biosolids. Biosolids at the rate of 0, 1,-.1, 2.2, 4.4, 8.8 and 17.6 Mg/ha and calcitic limestone at the rate of 0, 2.2, 4.4, and 8.8 Mg/ha were added to a myakka fine sand. Soil pH values were determined bi-weekly after the addition of lime and biosolids The N mineralization process at the various lime/pH levels was assessed by a non-leached incubation system. Soil samples were removed bi-weekly and extracted with water for the determination of NH_4 and NO_3. The soil pH values varied from 5.5 to 6.7 with increasing lime application rates. Increasing biosolids resulted in slight decreases in ssoil pH within each lime level. Ammonium was the predominant form of N within the first two weeks of incubation; however, as time progresses, NO_3 predominated. Nitrogen mineralization stabilized at 10 weeks and was reduced by the highest lime rate.

INTRODUCTION

Bahiagrass pastures in Florida are frequently under-fertilized although positive responses to N addition are obtained (Sveda et al., 1992). Reasons for that include reduced fertilizer inputs to lower production cost due to the low cattle prices, as well as coneems about environmental degradation (Muchovej and Rechcigl, 1994, 1995).

Application of biosolids (sewage sludge) to pastures has resulted in increase forage growth and quality, since it contain many essential nutrients, including N, P, and Fe. Furthermore, since sandy soils of Florida, which have a very low nutrient holding capacity, biosolids may be an important alternative slower release organic fertilizer for farmers to use. Results from a field study conducted on an acid sandy soil at the Rangd Cattle Research and Education Center, Ona, Fl (Muchovej, 1998; Muchovej 1997), indicated that pelletized biosolids application to pastures, at rates up to 17.6 Mg/ha, increased yield and quality of bahiagrass pasture linearly and that more than 50% of the N was made available within the first year of application. However, soil characteristics may heavily influence the rate of mineralization of nutrients from biosolids. Soil pH is quite variable in Florida, ranging from aeid (~4.5) to alkine (>7.5) and soil pH may have a pronounced effect on nutrient release from biosolids.

The objective of this laboratory incubation study was to investigate the effects of variable soil pH, attained by liming an acid sandy soil, and varying rates of pelletized municipal biosolidss on the mineralization of N from the biosolids.

MATERIALS AND METHODS

The soil used for the study was a Myakka fine sand and some of its characteristics are presented in Table 1. The biosolids product was of municipal origin and contained several essential and non-essential elements (Table 2). All experiments were conducted in a randomized complete design with 3 replications. Moisture retention capacity of each soil-biosolids mix was pre-determined. Water was added to each flask to obtain an "optimum" condition for microbial activity (approximately 70% of water holding capacity) and this moisture condition was maintained in all studies.

Table 1. Soil Characteristics of a Myakka Fien Sand (Sandy, siliceous hyperthermic Aeric Hapalaquod).

Horizon	Depth Cm	OM G/kg	C/N	pH	NO_3-N	NH_4-N ug/g
Ap	0-15	8.0	23	4.9	2.0	22
A22	15-30	1.0	6.0	5.9	2.0	2.0
Bh	35-45	29.8	50	4.6	0	0

Table 2. Composition of the Municipal Biodolids (Dry Weight Basis) (Average Values from 3 Analyses Performed).

Element	Concentration
N (TKN) (%)	4.14
NH_4-N (%)	0.35
NO_3-N (%)	<0.01
P (%)	1.91
K (%)	0.11
S (%)	3.43
Ca (%)	2.0
Mg (%)	0.60
Na (%)	0.15
Fe (ug/g)	14,400
Mo (ug/g)	4.75
Mn (ug/g)	430
Cu (ug/g)	777
Zn (ug/g)	1,105
Cd (ug/g)	7.47
Ni (ug/g)	45.9
Pb (ug/g)	26
PH	7.02

A preliminary study was conducted in which limestone, in the form of $CaCO_3$, at the rates of 0, 2.2, 4.4 and 8.8 Mg/ha, was added to 1 kg of soil, in triplicates, and placed in plastic bags. After homogenization, distilled water was added to bring the moisture content to 70-80% water retention capacity. Sub-samples were removed every 7 days for determination of water pH (1:10 soil:water ratio). The procedure was repeated for 7 weeks, when stability appeared to have been achieved (Table 2).

The soil was then air-dried and amended with biosolids at the following rates: 0, 1.1, 2.2, 4.4, 8.8 and 17.6 Mg/ha, and moisture content re-adjusted. Sub-samples were taken at 0, 21 and 42 days after the addition of biosolids and the water pH was determined (Figures 1a-d).

The mineralization process from pelletized biosolids at the various lime/pH levels was assessed in the soils by a non-leached incubation system (Keeney and Barmner, 1967; Keeney and Nelson, 1982; Ryan et al., 1973). For this experiment, the same lime and biosolids rates were applied to 50g soil and placed in Erlenmeyer flasks and optimal moisture restored. Incubation was done at approximately 24-30°C in a room equipped with a heating -

air conditioning unit, for a period of 26 weeks. At two weeks intervals, samples of approximately 2g (exact

Table 3. Soil pH after addition of lime as a function of time, before addition of biosolids

Time	0 Lime	1 lime	2 Lime	3 Lime
7 days	5.59	5.58	6.10	6.72
14 days	5.41	5.82	6.10	6.56
21 days	5.54	5.89	6.09	6.56
28 days	5.51	5.82	6.07	6.57
35 days	5.42	5.85	5.15	6.64
42 days	5.45	5.76	5.96	6.31
49 days	5.41	5.77	6.00	6.43

0L=no lime; 1L=2.2 Mg $CaCO_3$/ha; 2L=4.4 Mg $CaCO_3$/ha; 3L= 8.8Mg $CaCO_3$/ha

weight recorded) were removed from each flask and extracted with 20 ml of extracting solution. Two extractants, water and 2N KCL, were used in a 1:10 soil:solution ratio. The extraction with 2N KCL was done for NH_4 and NO_3 assessment (Garau et al., 1986). The soil extracts were maintained in a freezer until analyzed. Major (P, K, Ca, and Mg) and micro-nutrients (Fe, Mn, Cu and Zn) and NH_4 and NO_3 concentrations were determined in water extracts. All samples were analyzed at the Analytical Research Laboratory, University of Florida, Gainesville, Fl. Rates of mineralization of N were calculated as the sum of NH_4 and NO_3 present in the soil, taking into consideration the amounts present in the control treatments.

At the end of the incubation period, soil samples (2g/20ml) were removed and extracted with water and Mehlich 1 for analyses of major, micro and trace metal content.

RESULTS AND DISCUSSION

Soil pH values varied from 5.5 to 6.7 with increasing lime rates (Table 3). Increasing rates of biosolids resulted in very slight decreases in soil pH within each lime level (Figures 1a-d). This result is not unexpected since the pH of the biosolids used was in the vicinity of 7.0.

Nitrogen mineralization is presented as the concentrations of inorganic N ($NH_4 + NO_3$) for the incubation period. Values obtained for un-amended soils were subtracted from the biosolids treatments. Ammonium was the predominant form of N within the first two weeks of incubation; however, as time progressed, the predominant form was NO3 (Figures 2a,b.c), indicating the time required for nitrification to occur. The aerobic conditions maintained throughout the experiments are responsible for its prevalence over ammonium, especially in the absence of plants to absorb it. Since the incubation conditions were neither anaerobic (responsible for losses by denitrification), nor arid (volatilization losses due to lack of moisture) and there was no external factor removing N from the system, the tendency to stabilization is already evident during the incubation period. Some volatilization losses could be contributing, in part, to the reductions in total inorganic N with the highest lime rate. Nitrogen mineralization tended to reach a level of stabilization at 10 weeks and was reduced with highest lime rate.

At the lower biosolids rate a high priming effect was indicated, where N was mineralized from the soil organic matter fraction in addition to the N in the biosolids.

Since N was limiting, increasing lime rates had no effect on the concentration of inorganic N forms released. At all lime rates, mineralization of N from biosolids was close to or higher than 90% (Table 4). However, as the rate of biosolids increased, increasing rates of lime reduced N mineralization. Soil pH was increased from an average of 5.4 (0 Lime) to approximately 6.5 at 8.8 Mg $CaCO_3$/ha (Table 3). Therefore, one unit pH increase resulted in nearly 40% decrease in the N mineralized at 10 weeks.

For the soil:biosolids samples extracted at the end of the incubation period (Data not shown), water extracts presented no detectable Fe, Cd, Pb, Ni, Cl, and NH_4 or NO_3. Sodium was detected in the range of 2 to 6 ppm. The KCl extracts from the periodically removed samples contained between 8 and 15 ppm of NH_4 and 3 to 12 ppm or NO_3. This is expected since KCl is a stronger extractant for N forms than water. The concentrations of the other elements, extracted, extracted by Mehlich 1, appear to be within normal acceptable range (data not presented), and in nearly all the sample concentrations were not detected after the first 10 weeks of incubation. Concentrations of trace metals (pb, Cd, Ni) were below detection limits, with the procedures used for evaluations.

Table 4. N mineralization after 10 weeks of incubation, as percentage of the total, as affected by lime rates, at various biosolids rates.

Biosolids	0 Lime	1 Lime	2 Lime	3 Lime
1.1 Mg/ha	100	97.0	87.0	96.7
4.4 Mg/ha	100	67.0	68.0	58.0
17.6 Mg/ha	100	88.0	71.7	61.0

OL=no lime; 1L=2.2;Mg $CaCO_3$/ha; 2L=4.4 Mg $CaCO_3$/ha; 3L= 8.8Mg $CaCO_3$/ha

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REFERENCES

Garau, MaA., Felipó, M.T. and M.C. Ruiz de Villa. 1986. Nitrogen mineralization of Sewage sludges in soils. J. Environ. Qual. 15:225-229.

Keeney, D.R. and J.M. Bremmer. 1967. Determination and istotpe-ratio analysis of different forms of nitrogen in soils: 6. Mineralizable nitrogen. Soil Sci. Soc. Am. Proc. 31:34-39

Keeney, D.R., and D.W. Nelson. 1982 Nitrogen – Inorganic forms. P.643-698. In: Methods of Soil Analysis, Part 2. ASA-SSSA, Madison, W.I.

Muchovej, Rosa M. 1997. Beneficial Use of Residuals in Pasturelands, In: Biosolids Management in Florida: Beneficial Use of Domestic Wastewater Residuals. Florida Department of Environment Protection/Florida Center for Solid and Hazardous Waste Management, Tallahassee, F.. pp.29-33, 57-58.

Muchovej, Rosa M.C. and J.E. Recheigl. 1994. Impacts of Nitrogen Fertilization of Pastures and Turfgrasses on Water Quality. In Lal, R. and B.A. Steward (eds.) Soil Processes and Water Quality. Advances in Soil Science Series, Lewis Publishers, Boca Raton, FL pp. 91-135.

Muchovej, R.M.C. and J.E. Rechcigl. 1995. Nitrogen Fertilizers. In: J, E. Rechcigl (ed.) Soil Amendments and Environmental Quality. Lewis Publishers, Boca Raton, Fl. P. 1-64.

Muchovej, Rosa M. and J.E. Rechcigl, 1998. Nitrogen recovery by bahiagrass receiving varying qpplication rates of pelletized biosolids. In: Beneficial Co-utilization of Agricultural and Industrial By-products, ARS/U.S. Department of Agriculture, Beltsville, Maryland, S. Brown (ed.) (*In Press*).

Ryan, J.A., D.R. Keeney, and L.M. Walsh. 1973. Nitrogen transformations and **availability of an anaerobically digested sewage sludge in soil. J. Environ. Qual. 2:489-492.**

Sveda, R., J.E. Rechigl and P. Nkedi-Kizza. 1992. Evaluation of various nitrogen sources and rates on nitrogen movement, Pensacola bahiagrass production and water quality. Commun. Soil Sci. Plant Anal. 23:2451-2478.