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Short

Soil Moisture Regime Affects Variation Patterns in Concentration of Inorganic Nitrogen from Liquid Swine Manure during Aerobic Incubation

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Introduction

Since the advent of agricultural farming system, livestock manures have been traditionally used as effective organic fertilizers. However, the introduction of inorganic fertilizers into modern agricultural systems has corresponded with a decline in the use of animal manures. With increasing demand for meats and dairy products in Korea, the production of animal wastes has increased creating a serious waste management problem. According to the Ministry of Agriculture and Forestry of Korea, more than three million tons of livestock manure are produced every year and they account for about thirty percent of wastes disposed to ocean outfalls (NIAST, 2003); the majority of which is swine waste. As one of the environmental protection policies, the 1996 London Convention will completely ban the member nations to dump wastes in the ocean by 2012 (IMO, 2005). Pig farmers therefore should pay environmental stewardship for the disposal of swine wastes to the land.

Because swine manure contains macro- and micro-nutrients with significant fertilizer value, it can improve chemical and physical properties of the soil (Song et al., 2006; White, 1997). However, the use of swine manure as a soil ameliorant has been limited because it creates toxic gases such as methane, ammonia and sulfur-containing volatile compounds and is difficult to handle. To effectively cope with such negative aspects of liquid swine manure, raw swine manure should be processed or digested; one possible approach to optimizing the quality of swine manure for agricultural standards is to employ slurry composting and bio-filtration (SCB) technology developed by the National Institute of Animal Science (NIAS, 2000). However, once incorporated in the soil, nitrogenous compounds in the manure undergo transformation, which is controlled by abiotic factors such as soil moisture, temperature, and soil texture (Choi and Ro, 2003).

As a first step to evaluate the effect of abiotic factors on N transformation from swine manure, we aimed to study how the soil moisture regime influences variation patterns in concentration of inorganic N through a batch aerobic incubation.

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Materials and Methods

Loamy soil was collected in May 2007 from a field of experimental ranch at Seoul National University, Korea. Samples were air-dried and passed through a 2-mm sieve. The soil had 17.2 g kg^{-1} of soil organic matter content, 1.42 g kg^{-1}, of total-N content, 1.02 g and 122.0 mg kg^{-1} of total P and available P respectively, 4.1 mg kg^{-1} of Cu, 26.7 mg kg^{-1} of Zn, and 7.1 of pH (soil:solution=1:5) and 0.4 dS m^{-1} of ECe. Urea (CF), as a control, and raw liquid pig manures (LPM) and SCB liquid pig manures (SCB) were treated for comparison. The chemical properties of LPM and SCB were shown in Table 1.

Table 1. Chemical properties of raw and processed SCB liquid pig manures.

Parameters	LPM†	SCB‡
Total-N (g L^{-1})	1.26	0.87
NH_4^+-N (g L^{-1})	1.07	0.05
NO_3^--N (g L^{-1})	0.37	0.59
Total-P (g L^{-1})	0.44	0.08
Cu (mg L^{-1})	1.49	2.31
Zn (mg L^{-1})	10.73	17.86

† Raw liquid pig manure
‡ Processed SCB liquid pig manure

Incubation study Twenty-five gram of each soil sample was pre-incubated at 25°C for 10 days was placed in a 100 mL polyethylene bottle and mixed thoroughly with each of urea, and the two pig manures. Prior to mixing, soil water contents were maintained at saturation (S, = 0.55 m^3 m^{-3}) for saturated and at 33 kPa of soil moisture tension (FC, = 0.26 m^3 m^{-3}, approximately equivalent to field moisture capacity) for unsaturated conditions throughout the incubation by daily addition of distilled water as necessary to adjust their respective initial soil water content. In each treatment, urea, raw or SCB liquid manure was mixed at a rate of 150 mg kg^{-1}. The bottles were covered with perforated aluminium foil and subsequently placed into an incubator at 25°C in the dark and sampled in triplicate after 0, 3, 7, 14, 21, 35, 49, and 63 days.

Sampling and Analysis At each sampling, soils were analyzed for inorganic N (NH_4^+ and NO_3^-). Approximately 20 g of fresh soil was extracted with 100 mL of 2 M KCl, and 30 mL of each extract was steam-distilled using MgO and Devarda alloy (Keeney and Nelson, 1982) to determine the NH_4^+-N and NO_3^--N concentrations. Duplicate soil samples were ground into very fine powders and used for total-N and -C analyses. Total-N and -C concentrations of soil samples were measured using a continuous-flow stable isotope ratio mass spectrometer (IsoPrime-EA, Micromas, UK) linked with a CN analyzer.

Result and Discussion

Concentrations of NH_4^+-N for unsaturated soils decreased abruptly over time, while those for saturated soils decreased gradually to low concentrations except for LPM-S soils (Fig. 1). Concentrations of NO_3^--N for unsaturated soils, on the other hand, increased sharply during first 3 days due to rapid nitrification and thereafter remained unchanged, while those for saturated soils

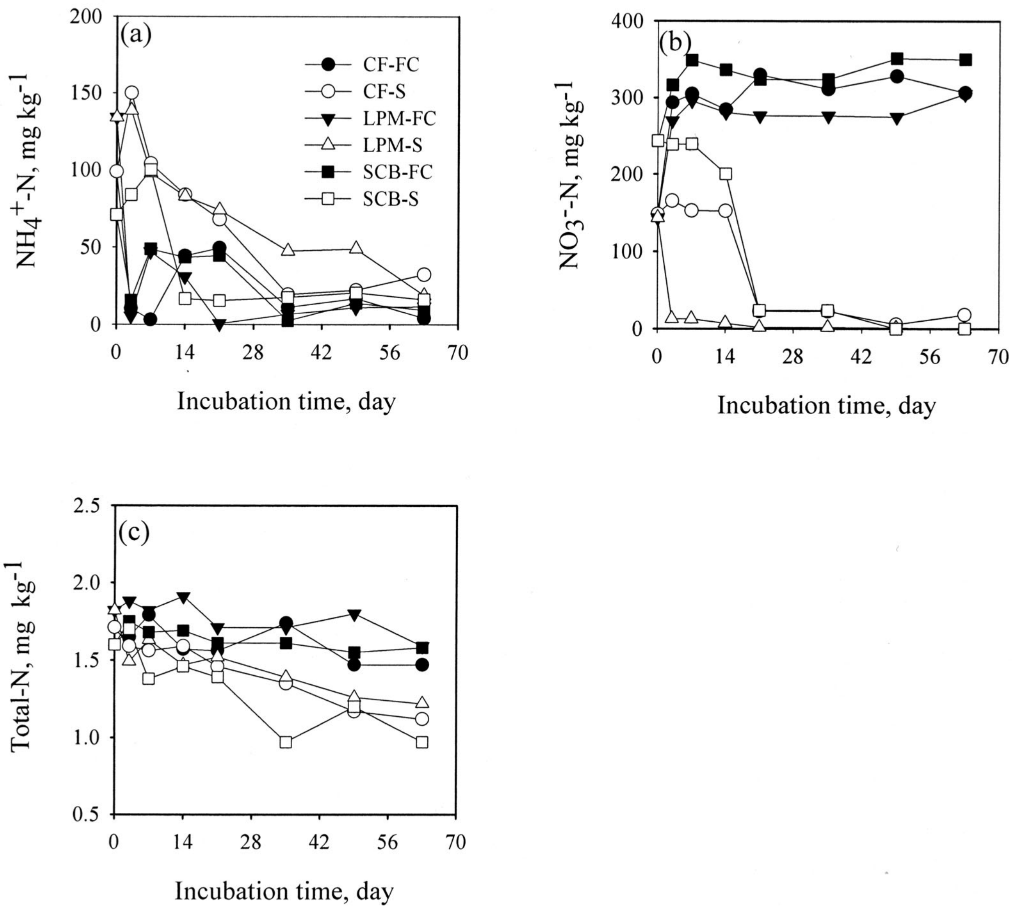

Fig. 1. Temporal changes in (a) NH_4^+-N concentrations, (b) NO_3^--N concentrations, and (c) total-N concentrations with time. CF denotes urea as chemical fertilizer; LPM denotes raw liquid pig manure; SCB denotes processed SCB liquid pig manure. FC denotes water content at field capacity; S denotes water content at saturation.

remained unchanged for two weeks and decreased abruptly to low levels except for LPM-S soils (Fig. 1). For LPM-S soils, concentrations of NO_3^--N decreased to low levels after 3 days of incubation.

The N losses in saturated soils are attributable to NH_3 volatilization and denitrification via nitrification under anaerobic conditions leading to hypoxic or anoxic environment. Considering the greater differences in NO_3^--N than in NH_4^+-N between the initial (just after treatment) and final concentrations, denitrification predominates over NH_3 volatilization, which is favored at slightly alkaline pH, to the N losses of inorganic N (Table 2). Of the abiotic factors controlling N transformation, sources of N fertilizers and soil moisture regime are regarded as the most important factors affecting denitrification in agricultural systems (Mosier and Zhaoliang, 2000). Total-N concentrations were virtually unchanged over time for unsaturated soil samples, but tended to decrease due in part to the decrease in inorganic N (Fig. 1).

The results of this study showed a possibility that liquid swine manure could serve as an alternative fertilizer resource, if properly processed, and that irrespective of N sources, higher concentrations of NH_4^+-N and lower concentration of NO_3^--N were maintained in saturated soils than in unsaturated soils. Accordingly, the results of this study showed that liquid swine manure had potential for use as an alternative fertilizer resource, if properly processed. The results of this study also demonstrated the need for a sound management strategy of liquid swine manure to obtain maximal N efficiency and minimal environmental degradation, since soil moisture regime interacts with N transformation.

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References

Choi, W.J., and H.M. Ro. 2003. Differences in isotopic fractionation of nitrogen in water-saturated and unsaturated soils. Soil Biol. Biochem. 35:483-486.

de Klein, C.A.M., and R.S.P. van Logtestijn. 1996. Denitrification in grassland soils in the Netherlands in relation to irrigation, N-application rate, soil water content and soil temperature. Soil Biol. Biochem. 28:231-237.

IMO. 2005. February 2005 A Summary of IMO Conventions. International Maritime Organization.

Keeney, D.R., and D.W. Nelson. 1982. Nitrogen-inorganic forms. p. 643-698. In A.L. Page et al. (ed.) Methods of soil analysis, part 2. Chemical and microbiological analysis (2nd ed.). Soil Science Society of America, Madison, WI, USA.

Meyer, R.L., T. Kjar, and N.P. Revsbech. 2002. Nitrification and denitrification near a soil-manure interface studied with a nitrate-nitrite biosensor. Soil Sci. Soc. Am. J. 66:498-506.

Mosier, A.R., and Z. Zhaoliang. 2000. Changes in patterns of fertilizer nitrogen use in Asia and its consequences for N_2O emissions from agricultural systems. Nutri.Cycl. Agroecosys. 57:107-117.

NIAST. 2003. Manufacture and utilization of compost and liquid manure for environmental friendly agriculture. National Institute of Agricultural Science and Technology, RDA, Suwon, Korea

NIAS. 2000. Development swine slurry evaporation system integrated aerobic and aerobic (SESA2) process. Research report of National Institute of Animal Science p. 53-79, RDA, Suwon, Korea.

Table 2. Differences in concentrations of inorganic N between the beginning and end of 63-day incubation. CF denotes urea as chemical fertilizer; LPM denotes raw liquid pig manure; SCB denotes processed SCB liquid pig manure. FC denotes water content at field capacity; S denotes water content at saturation.

Treatment	NH_4^+-N (mg kg^{-1})			NO_3^--N (mg kg^{-1})		
	Initial	Final	Difference†	Initial	Final	Difference†
			Field Capacity (FC)			
CF	98.7	4.0	-94.7	148.2	306.4	158.2
LPM	134.1	11.4	-122.7	143.5	305.4	161.6
SCB	70.8	9.25	-61.6	243.5	350.1	106.6
			Saturation (S)			
CF	98.7	32.2	-66.5	148.2	18.1	-130.1
LPM	134.1	18.6	-115.5	143.5	0.0	-143.5
SCB	70.8	15.9	-54.9	243.5	0.2	-243.3

† Difference in concentration of each inorganic N is calculated as final concentration minus initial concentration.

Song, S.T., M.C. Kim, and K.J. Hwang. 2006. Determination of nutrient contents of liquid pig manure and the correlation of components as fertilizer in western Jeju area. J. Kor. Grassl. Sci. 26:15-24.

White, R.E. 1997. Principles and practice of soil science: the soil as a natural resource (3rd ed.). Blackwell Science Ltd, Calton, UK.