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LEACHATE LOSSES FROM CATTLE MANURE AND GREENWASTE DURING COMPOSTING

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ABSTRACT

Macronutrient (ammonium-N, nitrate-N, phosphate-P and potassium) losses in leachate were monitored as a part of a series of experiments designed to assess nutrient turnover during composting of farm yard manure (FYM) and garden greenwaste (GR). Composting was conducted using 10-12 m^3 stacks under ambient conditions in order to assess the variations in nutrient losses that might be expected to occur in practice. Leachate nutrient concentrations from frequently turned FYM at the beginning of composting were typically in the range 50-200 mg l^{-1} NH_4-N, 1-6 mg l^{-1} NO_3-N, 50-20 mg l^{-1} PO_4-P and 1000-2000 mg l^{-1} K. Ammonium-N concentration declined during composting, while nitrate-N tended to increase as microbial mineralisation took place. Phosphate-P and K concentration in leachate showed less variation during composting. More frequent turning increased nutrient losses by leaching. Mixing greenwaste (C:N ratio 20:1) with FYM (C:N ratio 16:1) significantly reduced N, P and K losses.

INTRODUCTION

Composting of animal manures and domestic waste allows the recycling of nutrients and organic matter within the farming system, giving both agronomic and environmental benefit. Composting leads to a reduction in material mass, volume and water content, the suppression of potentially harmful pathogens and weed seeds and the production of a stabilised organic material that spreads more uniformly. Mass reduction (mainly water and carbon) following composting may be in excess of 50% (Inbar et al., 1993; Lopez-Real & Bapista, 1996). However, adverse environmental impacts can arise from the composting process, such as enhanced ammonia emissions (Martins & Dewes, 1992), and nutrient leaching (Petersen et al., 1998; Sommer, 2001). Composting is most effective when dealing with bulky, semi-solid materials with a C:N ratio in the range 20:1 to 30:1 with the ideal being around 25:1 (De Bertoldi et al., 1983). Clear delineation of the limiting parameters for controlled composting that is achievable by farmers will ensure greater uptake of composting and hence reduce pollution risk while at the same time enhancing the agricultural value of the product. Mixing materials with contrasting C:N ratios, such as cattle manure and greenwaste, offers an opportunity to reduce leaching losses and increase nutrient retention in manure heaps. Leachate volume and chemistry depends upon storage environment and turning regime. This paper describes leachate losses from farm yard manures during composting, and the impact these changes have on manure management in farming systems.

MATERIALS AND METHODS

Experiments were conducted on farm yard manure (FYM) collected from sheds housing youngstock, bedded on wheat straw, and garden greenwaste (GR) collected at a local

municipal recycling centre. Composting was conducted for periods up to three months on a gently sloping (8%) concrete apron, subdivided into 5 separate bays, each 5 x 5 m wide. Bays were isolated from each other by 0.4 m high walls, and were unroofed in order to simulate manure management on most farms. Compost stacks typically contained 10-12 m^3 of manure or greenwaste per compartment at the beginning of each experiment. Treatments for farm yard manure experiments (99/1, 99/2, 99/3) included turning frequency and the addition of extra straw to the composting manure. The experiment conducted with contrasting ratios of manure and greenwaste was conducted in 2001 (01/1). Composts were turned using either a tractor-mounted fore-end loader and rear discharge muck spreader. Samples of leachate were taken for chemical analysis on a regular basis, usually weekly, using a flow proportional sampler for 99 experiments, and manually for the 01 experiment. Selected leachate samples were analysed for NH_4-N, NO_3-N, PO_4-P, K, Ca, Mg, plus the total dissolved solid load. Selected results for soluble N, P and K are reported here. For further discussion see Gibbs et al. (2000).

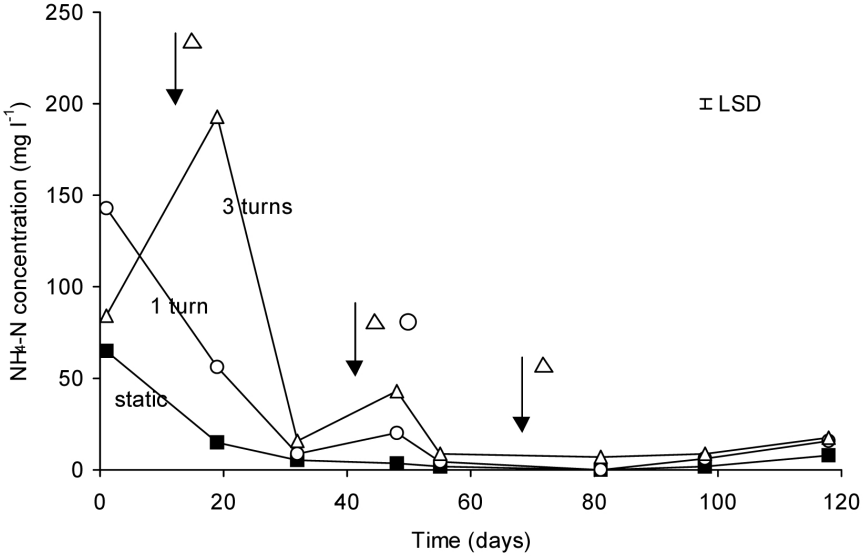
RESULTS AND DISCUSSION

Farm yard manure compost

Ammonium-N concentration in leachate for Experiment 99/1 is presented in Figure 1. The leaching of NH_4-N from the static (S) pile was significantly less ($p<0.05$) than all other treatments, with minimal losses following the initial decline (Day 0 to 30). The first turning of T3 treatment resulted in a significant increase in the concentration of NH_4-N leachate, for 10 days, compared to all other treatments. There was an overall increase in the mean concentration of NO_3-N in leachate during the experiment concomittant with the reduction in NH_4-N concentration. The effect of successive turns on the pattern of NO_3-N leachate is an overall increase in NO_3-N concentration following turning, with the leachate values declining shortly after turning. Analysis of leaching losses into turning periods shows that the largest proportion of nitrogen is lost in the first six weeks, and that when the compost pile is turned in this time period leached nitrogen can be as much as 2% of the original total N. Furthermore, rainfall also increases the nitrogen concentration of leachate with increased nitrogen leaching with increased rainfall. The concentration of nitrogen in the leachate closely matches that observed by Petersen et al. (1998) who observed 1 to 4 % losses of nitrogen from cattle manure.

Concentration of potassium (K) in leachate in Experiment 99/1 reached 1700-2000 mg l^{-1} K for the turning treatments, in comparison with 1100 mg l^{-1} K for the static heap leachate. Calculated losses exceeded 100% for some experiments, indicating inconsistencies in determination of loss values. Phosphorus (P) losses were considerably smaller, with maximum PO_4-P concentration in leachate of 250 mg l^{-1} for the 3 turned treatment, compared to 180 mg l^{-1} for the static treatment. The composting process generates heat, and results in the loss of water vapour, such that actively managed heaps, and in particular where composting is carried out undercover, do not generate leachate. Composting outdoors leaves the heaps exposed to natural rainfall, which can lead to significant generation of leachate containing dissolved and particulate nutrients (Eghball et al., 1997).

Figure 1. Ammonium-N concentration in leachate from farm yard manure under contrasting turning regimes. Arrows indicate turning events.



Patterns of leaching loss tend to depend closely on rainfall receipt. The manure heaps that were placed in the bays occupied typically 80-90 % of the bay floor area at the start of each experiment. Successive turning regimes reduced the mass and hence area of the manure heaps. Short-term differences in runoff from heaps were related to increased absorbance capacity of drier, actively composting manure. Results from Experiment 99/3 show that total leachate volume data for outdoor showed no consistent differences between bays, and was occasionally unreliable, due to malfunctioning counters. Discharge patterns followed closely that observed for the empty bay and matched rainfall receipt recorded at the adjacent automatic weather station. The undercover heap showed a significantly lower water content ($p<0.001$) at the end of the experiment (67%, compared to 79-83% for outdoor heaps). Insufficient leachate was collected from the undercover heap to sample and analyse.

Greenwaste compost

In Experiment 02/1, greenwaste compost with a mean C:N ratio of 20:1 was mixed with FYM (C:N ratio 16:1). Table 1 shows the concentration of mineral nitrogen, phosphate-P and potassium in leachate 14 days after the initiation of the experiment. For each nutrient, increasing the proportion of greenwaste in the compost stack resulted in a reduced nutrient loss. Greenwaste contains much recalcitrant organic material, much of it woody and fibrous. However, temperatures recorded in the manure heaps (in all cases >60°C) indicated that composting was not inhibited by lack of an available substrate, and that incorporation of such material can be an effective method of reducing losses of soluble nutrients from composting FYM.

Table 1. Variations in leachate composition from stacks with contrasting farm yard manure (FYM) : greenwaste (GR) ratios, measured 14 days after experiment initiation, and two days after a turning event. Values in columns followed by different letters indicate significant difference at p=0.05.

	Ammonium-N	Nitrate-N	Phosphate-P	Potassium
		mg l^{-1}		
100% FYM	147.7a	15.4a	77.3a	6260a
67% FYM:33%GR	109.1b	12.3b	68.3a	5044b
33% FYM:67% GR	31.5c	8.3c	20.5b	2600c
100% GR	16.0d	9.1d	9.5b	1073d

REFERENCES

De Bertoldi, M., Vallini, G. & Pera, A. (1983). The biology of composting: a review. *Waste Management and Research*, **1**, 157-176.

Eghball, B., Power, J. F., E., G. J. & Doran, J. W. (1997). Nutrient, Carbon, and Mass Loss during Composting of Beef Cattle Feedlot Manure. *Journal of Environmental Quality*, **26**, 189-193.

Gibbs, P. A., Parkinson, R. J., Fuller, M. P. & Misselbrook, T. (2000). Enhancing the effective utilisation of animal manures on-farm through compost technology. *Agriculture and Waste: Management for a Sustainable Future*., Edinburgh. SAC/SEPA. 63-72.

Inbar, Y., Hadar, Y. & Chen, Y. (1993). Recycling of cattle manure: the composting process and characterization of maturity. *Journal of Environmental Quality*, **22**, 857-863.

Lopez-Real, J. & Bapista, M. (1996). A preliminary comparative study of three manure composting systems and their influence on process parameters and methane emissions. *Compost Science and Utilization*, **4**, 71-82.

Martins, O. & Dewes, T. (1992). Loss of nitrogenous compounds during composting of animal wastes. *Bioresource Technology*, **42**, 103-111.

Petersen, S. O., Lind, A. M. & Sommer, S. G. (1998). Nitrogen and organic matter loss during storage of cattle and pig manure. *Journal of Agricultural Science*, **130**, 69-79.

Sommer, S. G. (2001). Effect of composting on nutrient loss and nitrogen availability of cattle deep litter. *European Journal of Agronomy,* **14**(2), 123-133.