

# Reducing nitrogen and potassium losses during farmyard manure composting by improving composting techniques

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**Abstract** - Based on literature findings the paper deals with the question, which circumstances are connected with nutrient losses and by which means this can be reduced. Nitrogen rich, particularly ammonia rich manures seem to be predestined to have high N losses. Some recommendations concerning C:N ratio, turning of the heaps, how to avoid seepage production etc. can be derived. Strategies are suggested how to achieve favourable composting conditions.<sup>1</sup>

## INTRODUCTION

The reduction of nitrogen (N) and potassium (K) losses during composting of farmyard manure to a tolerable, unavoidable extent makes sense for reasons of both agriculture (recycling of nutrients and organic matter) and environment (conservation of natural resources). To reduce losses requires to know first, in which factors and processes losses originate, and how the relevant parameters can be influenced. The problem is that composting is a complex system of mainly (micro)biological processes the relevant factors of which and their interactions are not yet fully understood. That's why Berg (2002) concluded that today no effective techniques to reduce emissions can be stated.

Nevertheless, we evaluated the scientific literature of the last 8 decades under this aspect. With selected publications (see below) we tried to clarify the factors responsible for N and K losses and emissions and, derived from that, to suggest effective techniques and strategies against them.

## MATERIAL AND METHODS

Approx. 200 International references about manure composting have been evaluated and selected for certain criteria: 1. investigations dealing preferably with solid cattle manure (because of the particular importance of these animals and solid manure housing systems in organic farming), 2. preferably with aerobic composting (as this method is more usual in organic farming), and 3. investigations with a proper methodology (e.g. turnover determination by weighing the total amount of fresh and composted manure or by nutrient contents based on ash). To manage the effort, we focussed on the period of manure storage not taking into account factors originating from the time before (e.g. feeding and housing animals) or after (e.g. spreading on and incorporating into the soil). Thus, approx. 45 publications have been used for a review (Raupp and Oltmanns, 2006) which is partly reported in this paper.

## RESULTS AND DISCUSSION

### Nitrogen losses

Nitrogen can be emitted as ammonia gas (NH<sub>3</sub>), nitrous oxide (N<sub>2</sub>O), gaseous nitrogen (N<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), nitrate (NO<sub>3</sub><sup>-</sup>-N), ammonia (NH<sub>4</sub><sup>+</sup>-N) or as dissolved organic compounds with seepage.

N losses vary between 5 and 70% of the original content with NH<sub>3</sub> being the largest fraction (Amon et al., 2001; Gibbs et al., 2002). The two main factors governing N losses seem to be the NH<sub>4</sub><sup>+</sup> pool at the beginning and the air supply during storage (Peigné and Girardin, 2004).

The turning of manure heaps does not make sense for reaccumulating oxygen in the material, as already 40 min later the oxygen mixed in may be respired again (Helm et al., 1995). In other investigations, too, the oxygen content dropped down to the previous level 1.5 hours (Brinton, 1997) or some hours (Michel, 1999) after turning. With increasing turning frequency (1-3 times) higher N losses have been observed (Parkinson et al., 2004). The earlier the manure has been turned, the higher the N losses have been. The authors concluded that turning once after the thermophilic stage may be able to reduce N losses. Probably the reason why too frequent turning can be harmful is that the material is chopped up and gets too dense so that ventilation is hindered. Additionally, turning always means an almost complete air exchange of the heap and by this way an extensive NH<sub>3</sub> release.

The higher temperature and pH values are (particularly under conditions of poor availability of carbon sources), the higher NH<sub>3</sub> emissions can be; for example, in an aqueous solution with pH 9.0 at 30°C approx. 50% of the ammonia is gaseous (Loehr, 1974). This process of abiotic NH<sub>3</sub> formation in manure has been confirmed in a laboratory experiment with sterilized cattle manure, as a man-made mixture of straw and slurry (Dewes, 1996). With pH < 7.5 no emissions occurred, but with pH 9.0 NH<sub>3</sub> losses 9.8% of the original content have been observed.

### C:N ratio

By mixing cattle manure with different amounts of straw, Ulén (1993) received manure types with a C:N ratio of 13 or of 28. The treatment with the wider C:N ratio had lower gaseous N losses, but there was no differences as regards P and K losses by seepage. In other experiments with cattle

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manure under outdoor conditions a reduction of N losses from 36.5 to 8.1% was found, when C:N ratio had been increased from 23.9 to 40.5 (Kirchmann, 1985). The same author reports on the effect of different carbon compounds on N losses. Straw, sphagnum peat or coniferous wood chips have been used as bedding material in a cattle stable. The manure types started composting with the same C:N ratio of approx. 18. After 136 days the manure with straw had the lowest N losses of 36.1%, the peat manure had 43.0% and the wood chips manure 53.4%.

#### Seepage

N losses by seepage are around or below 4% of the original N content (Ulén, 1993; Amon et al., 2001; Sommer, 2001) or even below 1.5% (Gibbs et al., 2002). Potassium losses, however, were 28% of the original K content in winter and 18% in summer (Ulén, 1993).

Water may run out of the heap, if rainwater rinses the unprotected heap. However, the heap-covering has not only positive effects under all circumstances. Three treatments of heap-covering (plastic film, air-permeable textile, uncovered) from the beginning had no effect on the amount of seepage and N leakage between day 1 and 177 (Dewes et al., 1991). The total amounts within the 177 days were 89-117 l m<sup>-3</sup> seepage with 89-119 g m<sup>-3</sup> nitrogen. Almost no precipitation occurred in that time. The water running out of the heaps obviously was the result of respiration and volume reduction of the material. This is supported by the fact that a large part was found already after 20 days: 55-81% of the total seepage and 71-87% of the total N leakage.

Of course, covering does not prevent seepage because of volume reduction or intense respiration. Even more, early covering during the thermophilic stage with impermeable material may prevent evaporation of water and, by that, support seepage production. A totally different thing is covering in later composting stages during cooling down. Then it can be very useful to cover the heaps, even with water-proof material, as temperature and evaporation are low, and with the additional water because of precipitation the water holding capacity of the material may be exceeded.

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