EFFECTS OF SEPARATION AND ANAEROBIC DIGESTION OF SLURRY ON ODOUR AND AMMONIA EMISSION DURING SUBSEQUENT STORAGE AND LAND APPLICATION

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ABSTRACT

A study was set up to investigate the environmental effects of anaerobic digestion and separation of slurry. Volatilisation of odour and ammonia from treated and untreated slurry were compared both during storage and following land application. It was found that ammonia volatilisation was higher from uncovered stores of anaerobically digested and separated slurry than from untreated slurry, however, when slurry stores were covered efficiently, the loss rate was low and equal for treated and untreated slurry. Ammonia volatilisation following land application was found to be lower from both anaerobically digested and separated slurry compared to untreated slurry. Treatment of slurry by anaerobic digestion and separation did not reduce odour nuisances during storage, however, odour nuisance from slurry stores was found to be efficiently reduced by an artificial crust cover of the slurry stores. During land application the odour nuisances were found to be lower for anaerobically digested and separated slurry than for untreated slurry
Keywords: *Odour, ammonia, slurry, technology.*

INTRODUCTION

The storage and handling of slurry may lead to considerable environmental impact in the form of odour nuisances and ammonia volatilisation. Ammonia volatilisation leads to reductions in the value of livestock manure as well as it may have a negative affect on the aquatic environment and on vulnerable natural areas (Bak et al. 1999). At the same time, the odour nuisances may injure the reputation of the farmers on a local as well as on a national basis. Ammonia and odorants are emitted from slurry in the form of gases generated in the slurry, and the extent of the emission will therefore largely depend on composition and handling of the slurry. This has lead to a considerable interest in how recent handling technologies like anaerobic digestion and separation of slurry effects emission of ammonia and odour during storage and land application of slurry.

The principle of slurry separation by means of a decanting centrifuge implies separation of the slurry into a dry matter fraction (fibres) and a considerably greater liquid fraction (liquid). The fibre fraction will normally be piled in the field for later use within plant production. The liquid is usually stored and applied the same way as ordinary slurry, but once it is separated, it will be thinner than unseparated slurry. The liquid will therefore infiltrates into the soil much easier after application. Separation may therefore reduce the time the slurry will be exposed to volatilisation of ammonia and odorants.

Anaerobic digestion of slurry increases the anaerobic (deoxidated) processes of the slurry with reference to increasing the production of methane (biogas), which is used for the production of electricity and heat. During the anaerobic digestion, some of the odorous components of the slurry will be degraded (Pain et al., 1990). During the process of the anaerobic digestion, the dry matter content of the slurry will moreover disintegrate. The slurry will thereby become thinner, and just like in the case of separation, the thinner slurry will infiltrate into the soil much easier, and thereby potentially reduce the emission of ammonia and odour.

MATERIALS AND METHODS

Prior to the investigations, the following technologies were used for treatment of freshly produced pig slurry:

- Untreated (Untreat)
- Anaerobic digestion in a mesothermophilous digestion unit (AD)
- Separation by a decanting centrifuge (Sep)
- Anaerobic digestion and separation by a decanting centrifuge (AD-sep).

After the treatment, 30 t of each slurry type were stored in equal slurry tanks under equal conditions, and the ammonia loss and the odour emission rates for each type of slurry were determined. The ammonia loss and the odour nuisances from the different slurry types were further determined in connection with the land application. All experiments were performed both in 2002 and 2003.

The ammonia loss during storage was measured in 2002 and 2003, respectively, by way of mass balance determination of the nitrogen content in the slurry before and after storage. In May 2002 and in May 2003, the ammonia volatilisation rates following slurry application in spring barley were determined for each slurry type by applying 30 t of slurry per ha by means of trailed hoses onto a number of 36 × 36 m test field sites. The ammonia volatilisation from each site was determined by use of a micro-meteorological mass-balance technique. Besides, the nutrient loss rate during storage of the fibre fraction was determined by means of a ventilated chamber technique.

The odour emission during storage for the differently treated slurry types were determined by covering the slurry stores with plastic for periods of 20 minutes, after which air samples were taken above the slurry surface. The odour concentrations in the air samples were then determined by an odour sensing panel. The procedure was repeated immediately after the slurry was stirred. The odour emission following land-application of slurry was determined by placing a static air chamber over the applied slurry types 0 and 240 minutes after the slurry application. The emitted odorants were then accumulated in the air chamber for 20 minutes, after which a number of air samples with a volume of 30 l were taken. The odour concentrations in the air samples were then determined by an odour sensing panel.

RESULTS AND DISCUSSION

Anaerobic digestion and especially separation reduced the dry matter content of the slurry (Table 1). This increases the infiltration rate of the slurry into the soil after application, which reduces volatilisation of ammonia (Sommer & Olesen, 1991) and the potential for odour nuisances following land application of slurry. However, anaerobic digestion of slurry also increases the pH-value of the slurry, which increases the risk of ammonia loss during storage and appli-

***Table 1**. Year of experiment and classification of tested slurry types.*

Year	Slurry type	Dry matter, %	pH	Total N, kg/t	NH_4 N, kg/t
2002	Untreat	3.4	7.4	4.3	3.1
2002	AD	3.2	8.1	5.2	3.7
2002	AD-sep	2.1	8.3	4.8	3.6
2003	Untreat	3.3	7.2	3.7	2.4
2003	Sep	1.5	8.6	4.9	3.9
2003	AD	2.8	8.1	4.3	2.9
2003	AD-sep	2.2	8.2	4.2	3.4

cation of the slurry.

In 2002, the slurry-stores were covered with a 15 cm layer of Leca (lightweight-expanded clay aggregates), which resulted in low nitrogen loss during the storage period for all the tested slurry types (Table 2). In 2003, it was decided not to cover the stores in order to study the effect of covering. The losses of nitrogen from the uncovered stores were considerably higher than from the covered slurry stores, and the highest losses were observed from the treated slurry types (Table 2). The higher loss rate from the treated slurry types was owing to the fact that anaerobic digestion increases the pH of the slurry and thus the potential for ammonia loss, and that the formation of a natural crust is impeded by preceding separation. This implies further requirement for preventing ammonia volatilisation from slurry-stores of anaerobic digested and separated slurry by covering the stores with effective crust layers or canvas covers.

Table 2. *Monthly relative loss of nitrogen from covered and non-covered stores with the four slurry types indicated as percentage of the initial nitrogen content.*

Storage period	Treatment	Untreat	AD	Sep	AD-sep
9/1-1/5 2002	+ covering	0.8	0.9	-	- 0.1
20/3-6/5 2003	- covering	2.5	4.4	6.1	4.4

Both anaerobic digestion and separation of the slurry prior to application led to reductions in the ammonia volatilisation during the application of slurry (Figure 1). In 2002 and 2003, respectively, the ammonia loss from applied anaerobic digested slurry made up 83 and 73% of the loss occurring from untreated slurry. Following separation of slurry, ammonia losses will occur both from the liquid fraction and during storage and application of the fibre fraction. In 2002 and 2003, the total ammonia loss from the liquid fraction and from the fibre fraction of separated anaerobic digested slurry made up 98 and 51%, respectively, of the loss occurring from untreated slurry, whereas in 2003, the total ammonia loss from separated slurry made up 40% of the loss occurring from untreated slurry.

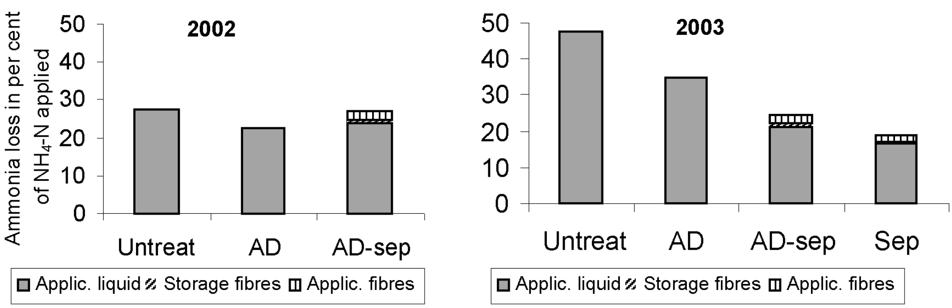

Figure 1. *Ammonia volatilisation loss in per cent of applied ammonium for the four slurry types. The ammonia loss was experimental determined on application of slurry and during storage of the fibre fraction and estimated for application of the fibre fraction. The studies were performed in the spring of 2002 and 2003, respectively.*

When the slurry stores were covered by an artificial crust consisting of 15 cm layer of Leca, the odour concentration in air sampled above the slurry was low and close to the detection limit (Table 3). When slurry was stirred prior to application, the artificial crust degraded temporarily which caused a significant increase in the odour emission (Table 3). The strongest odour emission in connection with agitation was observed from the anaerobic digested slurry types. This may be due to the fact that animal fat is added to the slurry before it is anaerobic digested in order to increase the biogas production. The addition of highly malodorous types of animal fat like fish and slaughterhouse waste may, therefore, increase the risk of odour nuisances during handling of anaerobic digested slurry.

Table 3. *Concentration of odour (odour units per m^3 of air) in the air above a store with the four slurry types before and after agitation.*

Treatment	Untreat	AD	AD-sep
Before agitation	200	100	100
After agitation	3000	15000	7000

Treated slurry types have a better ability to infiltrate into the soil because of their lower dry matter content. Therefore, lower odour emission rates were seen for slurry types that had previously been treated by anaerobic digestion or anaerobic digestion and separation (Table 4). The higher odour emission rates observed four hours after the application were probably due to the increase in the slurry temperature after the application.

Table 4. *Odour concentration (odour units per m^3 of air) in air samples of the four slurry types taken above trailed hose. The air samples were taken 20 and 260 minutes after the slurry application.*

Min after application	Slurry temp.	Untreat	AD	AD-sep
20	10.7	300	250	150
260	15.6	1000	450	150

CONCLUSIONS

The risk of ammonia losses during storage was observed to be higher for anaerobically digested and separated slurry, but effective covering of slurry stores will reduce the risk. Anaerobic digestion and separation of slurry was found to reduce the risk of ammonia losses during slurry application. The highest effect was achieved by slurry separation. Neither anaerobic digestion nor separation was found to be able to reduce odour nuisances from slurry stores. The odour nuisances from slurry stores were, however, reduced when the slurry stores were covered effectively. Following land-application of slurry lower odour nuisances were observed from anaerobically digested and separated slurry than for untreated slurry.

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