A low cost solution for ammonia emission abatement from slurry storage

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Abstract. A Leca® balls layer was evaluated for its ability to reduce losses of ammonia from the liquid surface of stored swine manure. An uncovered slurry tank partly embedded in the ground was divided into two halves by a plastic sheet. A 10 cm thick Leca® balls layer was applied to the surface of one half of the slurry tank. Ammonia emission was measured by means of the funnel technique floating on the slurry surface. Ammonia emitted from the Leca® balls covered and uncovered slurry, respectively, was measured simultaneously over time periods of 24 h for 6 consecutive days. Measurements were repeated in each of the four seasons during 1 year. Ammonia emission from the uncovered slurry ranged between 0.98 and 2.68 gNH₃/m², whereas from the surface covered with Leca® between 0.25 and 0.35 gNH₃/m² were emitted. Results pointed out a significant reduction of ammonia emission (up to 87%) due to the Leca® balls layer, what showed the persistency of this strategy for the whole time period of the trial. A first economic evaluation showed that Leca® results in an increase in slurry management costs of up to 4 Eurocent/m². © 2006 Elsevier B.V. All rights reserved.

Keywords: Ammonia emission; Low cost covers; Slurry storage; Leca® balls

1. Introduction

Ammonia emission from agricultural systems is of increasing public concerns due to its negative impact on health and environment [1]. National Emission Ceilings Directive Common Position requirements [2] are nowadays accelerating the search for effective solutions for the abatement of nitrogen losses to the air. Covering slurry tank during storage is one of the possible techniques suitable to reduce ammonia emission. However the use of various covering materials might influence the chemical and physical characteristics of the slurry [3]. Covers further have to meet different requirements such as...
as being easy to install and maintain, enabling to allow for easy and complete remove from slurry, and must preferably be cheap. The present study was carried out to assess the potential of a 10cm thick layer of Leca® to reduce ammonia emission from pig slurry during its storage over the four seasons of the year.

2. Materials and methods

A pilot scale concrete tank (10.0m in diameter, 4m depth) embedded 3m in the ground and filled with swine slurry was used in the present trial. The slurry surface was divided into two halves with the help of a plastic sheet leaving one half uncovered and the other half covered with a 10cm thick Leca® balls layer. Leca® is often used as insulating material and its physical properties allows it to float on a liquid surface such as slurry. Leca® balls consist of a porous material made from clay and coated with waterproof material. Ammonia emissions were measured by floating funnel systems [4]. This system consisted of a funnel of 0.138m² surface, a trap containing a 1% boric acid solution, a vacuum pump, a volume meter and a flow meter. The NH₃ concentration in the incoming air was measured by means of a second pump and acid trap. The funnel systems were arranged to collect the air from the captor with a flow rate of approximately 9l/min. Ammonia present in the air was fixed in the boric acid trap by being transferred into ammonium borate and its concentration was determined by titration. Each funnel was fixed on a frame made of polystyrene and wood and placed on the slurry surface (Fig. 1).

Three funnel systems were placed on each tank half so that emissions were measured simultaneously from the covered and the uncovered surface. Ammonia emission was measured over time periods of 6 consecutive days in which the boric acid traps were collected four times during the first 24 h and once a day on each of the following days.

Table 1
Main chemical characteristics of swine slurry

<table>
<thead>
<tr>
<th></th>
<th>Trial 1 (spring)</th>
<th>Trial 2 (summer)</th>
<th>Trial 3 (autumn)</th>
<th>Trial 4 (winter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM%</td>
<td>3.5</td>
<td>4.1</td>
<td>3.2</td>
<td>3.1</td>
</tr>
<tr>
<td>N_{tot}(*) (kg/t)</td>
<td>3.0</td>
<td>3.4</td>
<td>2.9</td>
<td>2.7</td>
</tr>
<tr>
<td>N_{ammon}(**) (kg/t)</td>
<td>1.2</td>
<td>1.0</td>
<td>0.8</td>
<td>1.1</td>
</tr>
<tr>
<td>pH</td>
<td>8.1</td>
<td>8.0</td>
<td>7.8</td>
<td>7.9</td>
</tr>
</tbody>
</table>

(*) Total nitrogen, (**) ammonium nitrogen.
The whole experiment consisted of four trials arranged over 1 year covering all the four seasons: spring (trial 1), summer (trial 2), autumn (trial 3) and winter (trial 4). Slurry temperature was measured continuously with a thermocouple connected to a data logger, whereas air temperature and humidity were measured with a thermo hygrometer. At the start of each trial, slurry samples were collected and pH, dry matter (DM), total nitrogen (Ntot) and ammonium nitrogen (Namm.) content were detected. Slurry was mixed prior to sampling.

3. Results

Main chemical characteristics of the slurry samples collected at the start of each of the four trials are presented in Table 1.

Ammonia emission from the uncovered slurry ranged between 0.98 and 2.68 gNH₃/m² day, whereas from the surface covered with Leca® between 0.25 and 0.35 gNH₃/m² day were emitted. Average air temperature during the four seasons was 6.3°C and 24.8°C in winter and summer, respectively, while during spring and autumn it averaged at 14.0°C. Ammonia emission was shown to be influenced by both air and slurry temperature. Therefore, ammonia emission (Table 2) was highest during the summer with slurry temperatures close to 25°C. Ammonia emission showed to follow slurry temperature pattern as shown in Fig. 2.

The reduction in gaseous ammonia losses from slurry storage achieved by covering its surface with Leca averaged at 73% (wintertime) and 87% (summertime) (Fig. 3).

4. Conclusions

According to the results obtained in the present study, covering slurry with Leca® is a reliable method to reduce ammonia losses from slurry surface over the whole year.

Table 2

<table>
<thead>
<tr>
<th></th>
<th>Trial 1 (spring)</th>
<th>Trial 2 (summer)</th>
<th>Trial 3 (autumn)</th>
<th>Trial 4 (winter)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gNH₃/m² day</td>
<td>gNH₃/m² day</td>
<td>gNH₃/m² day</td>
<td>gNH₃/m² day</td>
</tr>
<tr>
<td>Uncovered</td>
<td>1.55</td>
<td>2.68</td>
<td>1.36</td>
<td>0.98</td>
</tr>
<tr>
<td>Leca®</td>
<td>0.25</td>
<td>0.35</td>
<td>0.30</td>
<td>0.26</td>
</tr>
<tr>
<td>Slurry temp. (°C)</td>
<td>16.7 (12.3–18.1)</td>
<td>25.5 (25.0–26.0)</td>
<td>14.2 (12.3–18.1)</td>
<td>6.4 (6.2–6.6)</td>
</tr>
</tbody>
</table>

Fig. 2. Ammonia and slurry temperature patterns.
Results, in terms of ammonia reduction, are close to those of other Authors [6]. Apart from the environmental benefits, the extra nitrogen retained in slurry due to Leca® layer has a potential (even if small) cash value as natural fertilizer for plants [6]. Considering a slurry storage period of 180 days, a 10 cm thick Leca® layer on the slurry surface results in quite not marginal additional storage costs of around 0.04 Euro/m² slurry surface and day as the commercial price for Leca® is 76 Euro/m³. Since according to [5] Leca® is persistent even over longer storage periods, it might be reused in order to reduce costs. Effects of wind on the Leca® layer could not be evaluated in the present study as the slurry tanks used were of too small dimension to give any indications. This aspect as well as the CH₄ emission will be further investigated in order to determine the management assessment problem and the Leca® effect on the emission of the whole set of gases.

References