Measuring ammonia emissions from pig slurry using acid wet traps with two different protocols

Walter Antezana, Pablo Ferrer, Salvador Calvet and Fernando Estellés, Institute of Animal Science and Technology, Universitat Politècnica de València, Camino de Vera s/n, 46022, Valencia (Spain)

Abstract

Manure management is one of the main sources of ammonia (NH₃) emissions in Europe. Several mitigation options have been developed and are under investigation. In order to test the efficiency of these techniques, precise results on measurements of NH₃ emissions from manure samples are required. Acid wet traps are commonly used for accurate and non-expensive measurements of NH₃ concentrations. For field studies, these measurements are usually performed in a daily basis in order to determine daily average gas concentrations (Estellés et al., 2011). At the laboratory scale, a wide variation in ammonia sampling periods can be found in literature (Canh et al., 1998, Jarret et al., 2010, Cerizuelo et al., 2012, Pereira et al., 2011; 2012), thus to establish an adequate protocol for ammonia emissions measurement in terms of total duration and interval between measurements is critical. The main objective of this work was to evaluate the effect of the sampling period from 24 to 48 hours on the emission results. Pig slurry samples (5L each) were collected from 79 commercial pig farms located in two different areas of Spain (centre and east of the country). Slurry pits from four productive orientations were sampled: (piglets, fatteners, farrowing sows, and gestating sows). After homogenization of the samples, two replications of 0.5 L from each sample were used for NH₃ emissions measurements. Emissions were measured during 15 consecutive days using acid wet traps as described by Pereira et al., (2012). For the bulk of the samples, both replicates followed the same procedure and the acid from the wet traps was replaced every day. On the contrary, in 80 samples, each replication followed a different procedure: in one replicate acid was kept for 48 hours (A) and in the other replicate acid from the wet trap was replaced daily (B). The accumulated NH₃ emissions after 48 hours from the daily measurement were compared with the 48 hours measurement samples. NH₃ emissions were measured at 705 paired samples for a period of 24 hours of in vitro emission and a coefficient of variation CV% 12.53% was observed between replicates. 80 paired samples with different measurement frequency for a period of 48 h and a 8.31% variation was observed between the replicates were analyzed. The accumulated emission in 15 days was measured with different measurement frequencies being observed that the percentage variation between replicates measures was often 6.29% and when the measurement frequency is reduced variation was 6.24%. According to these results it can be conclude that, for long-term measurements, the emission measurement every 48 hours should not reduce the precision of the results for partial periods of 48 hours or for cumulative periods of 15 days.

Keywords: ammonia, pig slurry, impinger, protocol, error analysis
1 Introduction

Manure management is one of the main sources of ammonia (NH₃) emissions in Europe. The Food and Agriculture Organization of the United Nations (FAO, 2011), points out that the emissions of NH₃, nitrous oxide (N₂O) and methane (CH₄) associated with animal manure management is a global environmental issue. Developing mitigation strategies to reduce these emissions arises then as a key issue. To assess the efficiency of these mitigation strategies, precise measuring methods are required.

Several methods are available to determine NH₃ emissions from manure (Ni and Heber, 2010). Acid wet traps are commonly used for NH₃ airborne monitoring (Pereira et al., 2011; 2012). These methods are based on the collection of gaseous NH₃ in an acid solution and then determining ammonium concentration in the solution. The volume of air passed through the scrubber is recorded and the NH₃ concentration in the air is calculated. This method is commonly used under a 24-hours basis, in order to determine daily average concentrations (Galassi et al., 2010, and Estellés et al., 2011) or daily average emissions (Pereira et al., 2011, 2012 and Jarret et al., 2010).

NH₃ is being emitted from manure during several days after its exposure (Portejoie et al., 2004). In order to accurately determine potential NH₃ emissions from a manure source, different sampling periods can be found in literature, moving from 1 to 80 days (Canh et al., 1998, Jarret et al., 2010, Cerisuelo et al., 2012, Pereira et al., 2011; 2012).

In order to optimize resources, both materials, reagents and manpower, it is needed to define robust protocols finding a balance between cost and accuracy. In this regard, we wonder if the accuracy of the in vitro NH₃ emissions estimates is affected by the sampling frequency in acidic wet traps.

The objective of this study was to evaluate different protocols to determine NH₃ emissions from in vitro pig slurry samples using wet traps. This was conducted by modifying sampling frequency from 24 to 48 hours, and assessing emissions from individual measurements and 15-days accumulated records.

2 Materials and methods

Pig slurry samples from 79 commercial pig facilities were collected. Samples covered two areas (Central and Easter Spain) and four types of animals (piglets, fatteners, farrowing sows and gestating sows). From each slurry pit, a representative 5L sample of slurry was taken. Samples were refrigerated (5°C) during transport to the laboratory of the Institute of Animal Science and Technology (ICTA) of the Universitat Politècnica de Valencia (UPV). Once there, after homogenization, two sub-samples of 0.5 L were taken for NH₃ emissions determination.

2.1 NH₃ emissions measurement

The determination of potential NH₃ emissions from slurry samples was performed using a flux chamber and acid wet traps following the methodology proposed by Ndegwa et al., (2009). Figure 1 shows a scheme of the measurement set-up.
Each slurry sample (0.5 L) were analyzed by duplicate and placed in a 1 L chamber and kept at constant temperature (25°C) within a thermostatic water bath. This chamber was connected to a vacuum pump in which a constant flow rate of 1.2 ± 0.2 L/min was fixed. Exhaust air was forced to go through two impingers (in series) containing 100 mL of 0.1N sulfuric acid to capture the NH$_3$ emitted. At the end of each sampling period, the concentration of total ammonia nitrogen was measured following procedure 4500 of APHA (2005). Potential NH$_3$ emissions were determined during 15 consecutive days, thus reporting total NH$_3$ emitted (mg/L of slurry) during this period NH$_3$-15.

Acid from impingers was replaced (and analyzed) every 24 hours following the standard measuring procedure (Hernández et al., 2011, Pereira et al., 2011) for most of the samples (P24H). However, for 80 of the samples, one of the replications, was kept during 48 hours and accumulated the ammonia emitted during these two days (P48H). This protocol allowed comparing whether there was an effect of sampling interval on total emissions.

### 2.2 Statistical evaluation

NH$_3$ emissions (mg/L of slurry) obtained with different sampling protocols (P24H and P48H) were subjected to descriptive statistical analysis. Two different approaches were followed:

a) Replicates from the same sample and experimental sampling day measured following both protocols (P24H and P48H) were compared (e.g. Replicate 1 results from days 1 and 2 measured following P24H were compared with results from Replicate 2 from day 2 [accumulated from days 1 and 2] measured following P48H).

b) The variation between replicates of the same sample on NH$_3$-15 obtained following different sampling protocols (P24H and P48H) was also assessed.

Results were subjected to analysis of variance, the percentage variation (CV%) was established and applied the test for comparison of means of T and F with the SAS (2008) statistical package.

### 3 Results and Discussion

#### 3.1 Effect of different sampling protocols on individual measurements

The average emission of NH$_3$ (mg/L of slurry) for a period of 48 hours adding two measurements (obtained following P24H) was 136.85±5.92 mg/L of slurry while the same result obtained following P48H was 138.37±6.36 mg/L of slurry. According to the analysis of variance no significant differences (P=0.686) were found between results obtained following both protocols. Means comparison tests (T and F tests) provided the same results (Figure 2).

In this case, the CV of individual results obtained from replicates measured during both protocols was 8.3%, lower than the average CV between samples measured using the same protocol (12.5%). This could indicate that the difference found between results obtained using both protocols lie in the range of normal deviation between replicates.
Figure 2. Comparison of means (LSD) of NH$_3$ emissions accumulated during 48 hours using both protocols (P24H and P48H).

3.2 Effect of different sampling protocols on accumulated emissions

For accumulated NH$_3$ emissions (NH$_3$-15), average results obtained when determining NH$_3$ emissions in a daily basis (P24H) was 974.57±62.21 mg NH$_3$/L of slurry. When the number of measurements was reduced by including 48 measurements (P48H) alternately in both replicas, an accumulated average emission of 927.33 ±94.41 mg NH$_3$/L of slurry was obtained. Analysis of variance and mean test indicates that the differences were not statistically significant (P=0.726) as shown in Figure 3.

Figure 3. Comparison of means (LSD) of NH$_3$ emissions accumulated during 15 days using different frequencies (P24H and P48H).

The CV of NH$_{3-15}$ results between replicates obtained following the daily sampling protocol (P24H) was 6.30%, while when sampling was reduced and (P48H) used, the CV was 6.24%. In both cases, the variation between replicates may be produced by intrinsic factors particular slurry and the in vitro fermentation system and controlled flow of air method.

According to these results we can conclude that the variation between replicates is not affected by alternating and reducing the frequency of emissions from one to two days,
suggesting the possibility of reducing the frequency of measurements in tests of NH₃ emissions from slurry with an accuracy of similar quality, in long-term measurements.

4 Conclusions

The sampling frequency (replacing acid after 24 or 48 hours) of in vitro NH₃ emissions measurement from pig slurry, under controlled laboratory conditions, does not affect results for partial periods of 48 hours or for cumulative periods of 15 days.

5 Acknowledgements

This work was supported by the Ministry of Science and Innovation (Project AGL2011-30023-C03) and the Generalitat Valenciana (ACOMP/2013/118).

6 References


