Measuring Ammonia Emissions from Urine Puddles

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Summary

The ammonia emission from simulated urine puddles under controlled conditions was measured for a range of temperature, airspeed and concentration levels to determine if any or all of these factors affect the rate and amount that ammonia is produced from urine puddles on the floor of a barn. The measurements provide a basis for considering the effect of ammonia emissions from urine puddles on the amount of ammonia production and the ammonia production pattern in a swine barn.

Introduction

The slurry pit and urine puddles on the slatted and solid floor have been identified as the main sources of ammonia in a pig-housing unit. In urine puddles, the urea excreted by the animal is converted to ammonia by the enzyme urease on the floor surface. These enzymes are considered prevalent on barn floors because fecal bacteria produce them. As ammonia is being produced by the breakdown of urea, ammonia is also being released from the puddle to the surroundings. The relative rates of the urea breakdown and ammonia volatilization determine how much of the urea is converted to ammonia (and therefore the total emission), and the length of time required to release all the ammonia to the surroundings.

Experimental Procedures

The simulated urine consisted of urea and distilled water, with Jack Bean urease added to the solution to start the emission process. Each "puddle" was 250 ml of solution contained on a glass plate in an emission chamber. For each puddle, temperature and airspeed over the puddle surface were controlled and measured. Twelve treatment combinations were tested that included one of three temperatures (16, 21 and 26°C), either 0.1 or 0.18 m s-1 airspeed over the puddle surface, and an initial urea concentration of either 0.2 M or 0.4 M. The ammonia concentration inside the emission chamber was used to determine the total emission, and periodic samples taken of the puddles were used to determine the ammonia concentration in the liquid and the pH.

Results and Discussion

Based on the measured emission, plus the amount of ammonia still left in the solution (if any) at the end of the tests, approximately 86% (range 79 to 96%) of the urea was converted to ammonia. There is no distinguishable pattern as to the effect of temperature, air velocity or initial urea concentration on the percent of urea converted. At this point, the results lead us to assume that for the range of conditions tested, there was sufficient time for the enzyme to convert the majority of the urea to ammonia, and temperature, air velocity or urea concentration do not have a large impact on the total amount of ammonia produced by urine puddles.

However, there were differences in the emission pattern for different levels of each variable. Since the puddles emitted differing amounts of ammonia based on the initial urea concentration and potentially, the amount of enzyme, the time required for the puddles to emit 75% of the available ammonia were compared. The minimum amount of time required by a puddle to emit 75% of the available ammonia was 19h (26°C, 0.18 m s-1, 0.2 M). Urine puddles that started with 0.4 M urea took an average of 26% longer to reach the same point in the emission process as 0.2 M puddles. By decreasing the airflow rate across the puddle surface to 0.1 m s-1, the emission process required 28% more time than puddles with an airspeed of 0.18 m s-1. Higher temperatures resulted in faster emission rates. Urine puddles at temperatures of 16°C and 21°C required 52 and 24% more time than a puddle at 26°C.

These measured results will also be compared to a mathematical model currently in development that attempts to define what processes the temperature, air velocity and urea concentration affect.

Implications

Where this information is useful, is by knowing when and where urinations occur on the floor of barns, we can have a better understanding of when that particular surface is at its maximum emission. Further understanding the floor emission will help determine if and what kind of ammonia mitigation methods could be employed for this ammonia production site.

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