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Effect of urease inhibitor application on urease activity in three different cubicle housing systems under practical conditions

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ABSTRACT

The reduction of ammonia emission from animal husbandry is required due to detrimental and harmful effects on environment, health and fertilizer value. Nevertheless, practicable measures with a high ammonia mitigation potential, which can be implemented in existing dairy housing systems without significant constructional changes, are still rare. A possible reduction option, not previously used in practice, is the application of urease inhibitors on floor surfaces in dairy houses. Urease inhibitors inhibit the enzyme urease, which is responsible for the release of ammonia. It can, therefore, be assumed that a reduction of the urease activity always results in ammonia mitigation. Cubicle housing systems for dairy cattle differ in technical, climatic and organizational conditions. Consequently, tests on three different housings in three seasons have been carried out in the current study to evaluate the use of urease inhibitor in practice. The effect of the urease inhibitor was investigated based on detection of urease activity. A significant correlation of floor surface temperature and level of urease activity was observed. The current study shows that the application of a novel urease inhibitor resulted in overall average reduction of urease activity of 80% at dairy housing systems and at different seasons.

1. Introduction

Ammonia (NH_3) emission from livestock has detrimental effects on environment, health and fertilizer value. The reductions of NH_3 emissions are determined by the UN/ECE Protocol, which has been devised to abate acidification, eutrophication and ground-level ozone. Signed by Germany in 1999, the protocol demands a total reduction of total NH_3 emissions to 550 kt per year until 2010 (UN/ECE, 1999). This corresponds to a relative reduction of about 28% based on the year 1990, which was set as reference year. Fig. 1 shows the temporal course of total NH_3 emissions between 1990 and 2012 in Germany. The national emission ceiling based on UN/ECE (1999) has been exceeded every year with the exception of 2010 and 2012. Since a further reduction of emissions has already been agreed in the revised UN/ECE protocol in 2012 (UBA, 2013b), compliance with the current national emission ceilings a continued reduction of NH_3 emissions is still necessary.

NH_3 is formed by the breakdown of urea through the reaction with the enzyme urease. Biermann et al. (1996),Petersen et al. (1998) and Van Horn et al. (1996) investigated urea and nitrogen excretion in dairy cows. They found that the largest part, 60–80% of the nitrogen and 64–97% of the urea, was excreted in urine and only 20–40% in feces. The nitrogen contained in urine is bound mainly in the form of urea, which is rapidly hydrolyzed to ammonium by microbes (Mason, 2004). Urease is produced by microorganisms in the feces (Varel, 1997) and is ubiquitously present on the housing floors. If feces and urine mix on the surfaces of dairy livestock buildings, NH_3 is released. A high proportion of NH_3 emission from animal husbandry is formed on the floor of dairy housing systems (Braam and Swiestra, 1999). This is due to large space requirements per cow, large amounts of feces and urine per cow (Braam and Swiestra, 1999).

The urease activity can be estimated by the degradation rate of urea to ammonium ions. The activity (Table 1) is influenced by temperature, pH, concentration of urea, NH_3 and NH_4^+ content in manure, age of manure, organic matter and surface characteristics (Braam and Swiestra, 1999; Dittberner, 1996; Hasan, 2000; Merrick and Edwards, 1995; Mobley and Hausinger, 1989; Moyo et al., 1989; Palmieri, 1970; Pertit et al., 1976; Todd and Ming, 2001; Zantua and Bremner, 1977).

Urease inhibitors inhibit the enzyme urease, decrease the urease activity and block the hydrolysis of urea to NH_3 (Leinker, 2007; Varel, 1997; Varel et al., 1999).

The aim of this study was to test the on-farm application of a laboratory-proven urease inhibitor in dairy housing systems and to

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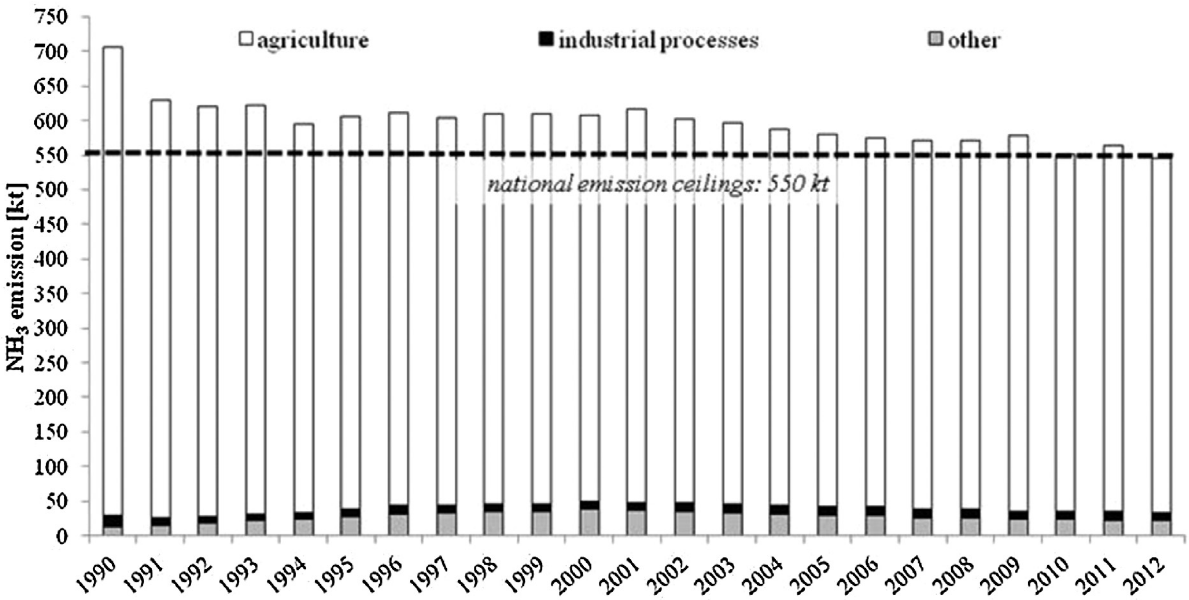

Fig. 1. Temporal course of total ammonia emissions with the national ceilings from 1990 until 2012 in Germany (UBA, 2013a).

examine its effect on urease activity under practical housing conditions.

2. Materials and methods

The urease inhibitor was tested on three different dairy housings (Table 3, Fig. 2). The testing was carried out on farm 1 in the autumn of 2011 and the summer of 2012, on farm 2 in the summer of 2012 and on farm 3 in the winter of 2013. Two variants were tested: in the summer (farm 1 and 2), the whole exercise area inside the dairy housing was treated with urease inhibitor, while treatment in the autumn (farm 1) and in the winter (farm 3) was limited to different parts of the exercise area inside the dairy housing.

2.1. Experimental housings

Experiments on farm 1 were carried out in a cubicle housing system with solid floor, three animal groups and a total of 176 dairy cows. The floor in the housing consisted partly of rubber mats (animal groups I, II and III), concrete-rhombuses (group III) and mastic asphalt (groups I and II). The manure removal of the floor surfaces was performed with stationary scrapers once per hour (group I and group II) or twice per hour (group III) and shifted the feces and urine mixture to the discharge channels in the middle of the housing.

Farm 2 comprised a cubicle housing system with one animal group and a total of 180 dairy cows. The floor surface consisted of concrete slats. Under the slatted floor there was under-floor storage area for liquid manure. The manure on the entire resting area and indoor feeding area was, in addition, removed with a tractor twice a day. The manure of the outdoor feeding area was not removed.

The dairy housing in farm 3 was a cubicle housing system accommodating approx. 300 cows. Out of these, 56 cows were available for the test. The floor surface consisted of concrete columns. Beneath the slatted floor there was under-floor storage area for liquid manure. The manure was removed every two hours by means of stationary scrapers. The four pens used for urease activity measurement with 14 cows each were located inside the housing.

2.2. Experimental setup

Two different measuring approaches were tested in the current study. The possibility of a separation of groups of animals, manure storage, treated and untreated areas was not available on all housings. For this reason, two different approaches were tested:

Table 1
Parameters influencing urease activity (according to Leinker, 2007).

Parameter		Literature
Temperature optima	Up to 65 °C 70–80 °C	Moyo et al. (1989); Dittberner (1996); Zantua and Bremner (1977)
Moisture (in the ground)	50–70% WHC (water holding capacity)	Sahrawat (1984)
pH	pH 6–8	Hasan (2000) Mobley and Hausinger (1989)
Concentration of urea, NH_3, NH_4^+	Affects the synthesis of urease	Merrick and Edwards (1995)
Age of slurry	The fresher the manure, the higher the urease activity	Todd and Ming (2001)
Cation exchange capacity	Salinities over 0.5% NaCl reduce the urease activity	Shi et al. (1994)
Organic matter	The more organic matter, the higher the urease activity	Palmieri (1970) Pertit et al. (1976)
Surface	The rougher the higher urease activity	Braam and Swiestra (1999)