FEASIBILITY OF DIFFERENT BEDDING MATERIALS IN LOOSE HOUSING SYSTEMS FOR DAIRY COWS

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1 INTRODUCTION

There is a growing interest amongst dairy farmers for new housing systems with improved cow comfort and less environmental impact. A loose housing system with an enlarged lying area for cows with soft bedding material like compost, sand or dried solid manure seems to be a promising solution. Although these systems are used in Minnesota (USA) and Israel, little is known about their environmental effects, particularly gaseous emissions and their behaviour under Dutch climate conditions. A research program commissioned by the Dairy Board and the Ministry of Agriculture, Nature and Food Quality was set up to study welfare implications and environmental effects of these housing systems under Dutch circumstances. The first phase of this program contained several studies. Two of them, Smits and Aarnink (2009) and Smits *et al.* (2009), are presented in this paper The aim of these studies was to determine the drying potential of different bedding materials under Dutch climate conditions using a model approach, and to determine ammonia emission from different bedding materials in laboratory experiments.

2 MATERIAL AND METHODS

2.1 Drying potential using a model approach

Water evaporation from different bedding materials used as bedding material in loose housing systems for dairy cows was modeled. The beddings materials were a mixture of soft compostable, or non compostable materials with animal excreta. Two available models on composting and drying were combined: a composting model by Cekmecelioglu *et al.* (2005) and a model describing the evaporation of water by Gigler *et al.*(2000a and 2000b). The estimated water flux from urine and feces that is excreted on the bedding was integrated in the model approach. Models were integrated using MATLAB. Model calculations were performed to compare the order of magnitude of evaporation from the bedding area under climate conditions in the Netherlands, Israel and Minnesota (USA) at different airspeeds over the naturally ventilated bedding (0.08, 0.32, 1.28 and 5.12 m/s) and with 18 m^2 available area per cows.

2.2 Gaseous emissions

The ammonia emissions of different bedding materials was measured in a laboratory set up. To represent non-degradable materials rubber shavings and two types of sand (coarse and fine) were tested. The degradable materials included freshly produced separated manure (the solid fraction from a screw press), with and without an added mixture of sawdust and wood chips, composted solids from a screw press and dewatered dredge from cleaning ditches in a peat soil area with a top layer of clay (see table 1). One week before the ammonia measurements, each of the bedding materials was mixed with fresh dairy cattle feces, urine and press screwed manure to get a quick simulation of the excreta accumulation in beddings in loose housing systems. The non degradable materials were subjected to two treatments differing in the amount of screw pressed manure that was added to simulate an on farm partly removal of feces from the beddings. After preparation the bedding-excreta mixtures were stored under well ventilated conditions. After one week they were brought to the laboratory and the material was put in cylindrical vessels. The degradable materials were also subjected to two treatments, compacted and not compacted to simulate an on farm situation with the bedding being loosened up by (mini) tractors. The compaction was performed after the material was put in the vessels and was comparable was comparable with a small tractor. Ammonia emission was measured in a laboratory set up (see figure 1) right after 75 ml urine was applied on material in the vessels to simulate a urination.

TABLE 1 **List of used non-degradable (1-6) and degradable (7-14) materials and applied treatments**.

Nr	Sample	Amount of feces	Compacted
1	Coarse sand	Low	No
2	Fine Sand	Low	No
3	Rubber shavings	Low	No
4	Coarse sand	Medium	No
5	Fine Sand	Medium	No
6	Rubber shavings	Medium	No
7	Press screwed manure	High	No
8	Press screwed manure with sawdust and wood chips	High	No
9	Composted press screwed manure	High	No
10	Dredge	High	No
11	Press screwed manure	High	Yes
12	Press screwed manure with sawdust and wood chips	High	Yes
13	Composted press screwed manure	High	Yes
14	Dredge	High	Yes

Two vessels with dairy slurry were measured as a reference, - one with the simulated urination (R1) and one without (R2). All ammonia emission measurements were done in duplicate and measured at 4, 24 and 72 hours.

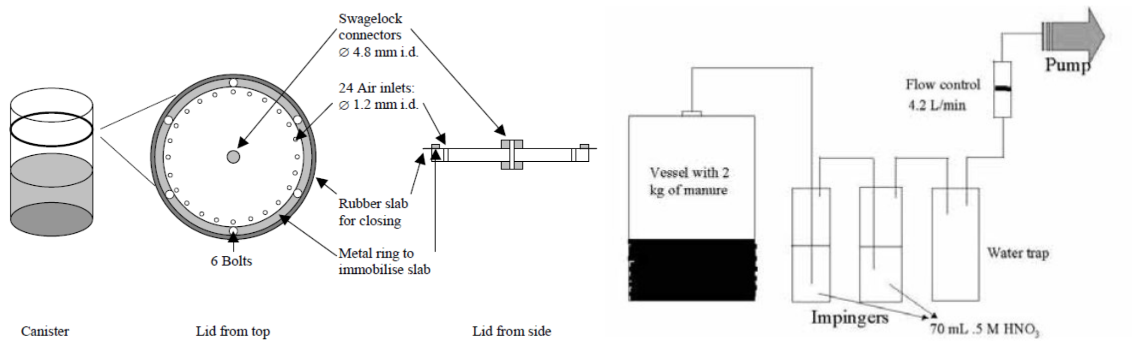

FIGURE 1 **Overview (right) of experimental setup for measuring ammonia emissions and detail (left) of the lid of the vessel (=canister).**

3 RESULTS AND DISCUSSION

3.1 Drying potential

Climate conditions in The Netherlands differ from those in Israel en Minnesota (USA). Figure 2 gives an overview of the average course of temperature and relative humidity over a year in Israel (Jerusalem), USA (Minnesota) and The Netherlands (De Bilt).

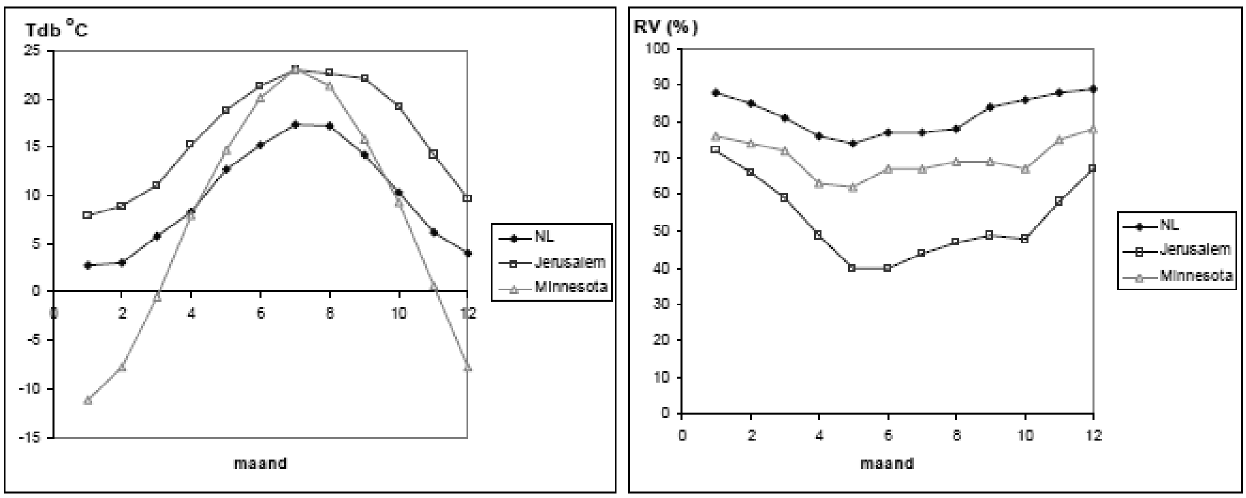

FIGURE 2 **Overview of monthly average dry bulb temperature and relative humidity in Israel (Jerusalem), Minneapolis (USA) and De Bilt (Netherlands).**

Temperatures in Israel are between 5.2 and 6.4^{o}C higher than in The Netherlands. Temperatures in Minnesota are higher in summer and lower in winter compared to The Netherlands. Relative humidity in The Netherlands is always higher than in Minnesota and Israel. Climate conditions from months 1, 3, 5, 7, 9 and 11 were used as input for the composting and evaporation models. Results of the model calculations are given in Figure 3 and 4.

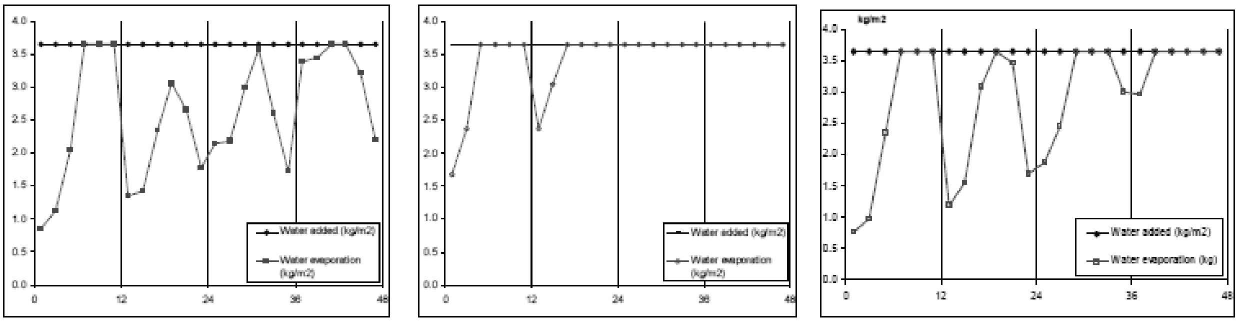

FIGURE 3 **Modeled water evaporation (kg/m^2) with composting for conditions in The Netherlands (left), Israel (middle) and Minnesota (right) at airspeeds of 0.08 m/s (0-12 months), 0.32 m/s (12-24 months), 1.28 m/s (34-36 months) and 5.12 m/s (36-48 months).**

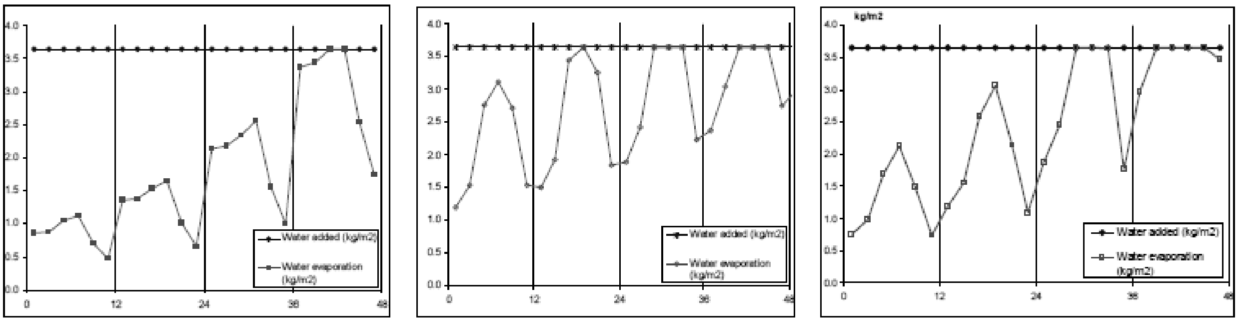

FIGURE 4 **Modeled water evaporation (kg/m^2) without composting in The Netherlands (left), Israel (middle) and Minnesota (right) at airspeeds of 0.08 m/s (0-12 months), 0.32 m/s (12-24 months), 1.28 m/s (34-36 months) and 5.12 m/s (36-48 months).**

In The Netherlands, and without composting, it is only possible to balance the water input and evaporation during summer months at airspeeds of more the 5 m/s. Higher air speeds results in higher evaporation but also in a higher sensible and latent heat loss. That is why with composting the best results are achieved at an airspeed of only 0.08 m/s. However, the water input and evaporation are only balanced in summer months. A system to drain the excess of water seems inevitable. On farm pilot experiments with bedding materials and management are needed to test whether or not it is possible to keep the top layer of the bedding at an acceptable level of dryness under cold and moist Dutch weather conditions.

3.2 Gaseous emissions

Relative emission of ammonia after 4, 24 and 72 hours after the simulated urination for degradable and non-degradable materials in the second replication is presented in figure 5. Emission after 72 hour of sample 13 is set to 100%. Most of the ammonia was emitted during the first 24 hours after the application of urine. Emissions from non-degradable materials tends to be higher than degradable materials even when the emission seems not to be stable. The rubber shaving gave the lowest ammonia emission from the group of non degradable materials. Compacted degradable samples seems to have a higher emission than the non-compacted samples of the same material. This does not apply for the dredge sample that have an unexpectedly low ammonia emission both for the compacted and the non-compacted samples.

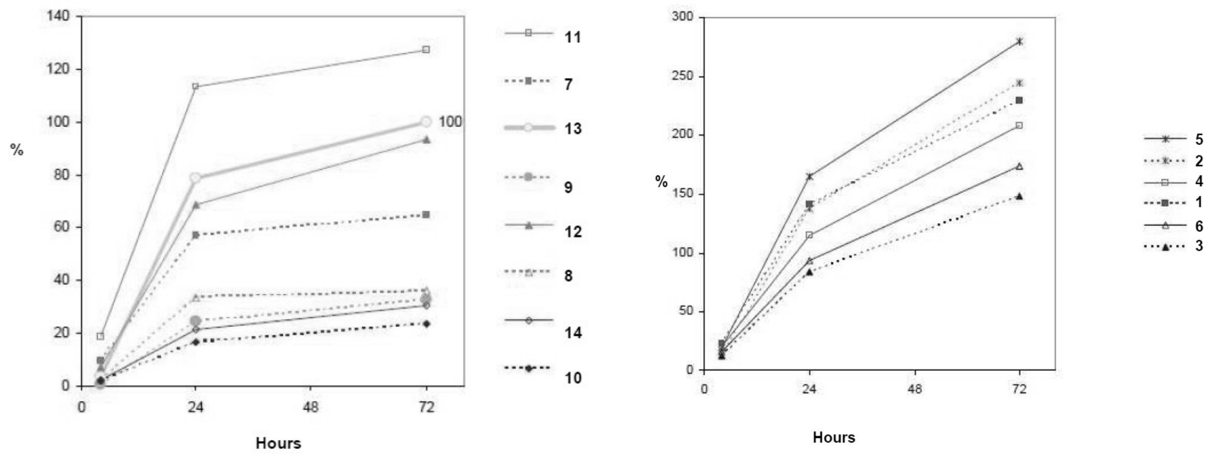

FIGURE 5 **Relative emissions (Sample 13=100%) of the different samples during the second experiment 4, 24 and 72 hours after simulated urination for degradable (left) and non-degradable (right) materials.**

4 CONCLUSIONS

Model calculations showed that to keep the bedding dry shows under Dutch climate circumstances composting is needed as a extra heat source. Without composting the moisture balance was negative. During composting the air speed should stay below 0.32 m/s to avoid the excessive loss of heat. The laboratory experiments showed that non-organic bedding material resulted in a higher ammonia emission. Rubber shavings and dewatered peat dredge showed the lowest ammonia emission from non-organic and organic bedding materials respectively. Compacted bedding material resulted in a higher ammonia emission. Most of the ammonia was released in the first 24 hours after a simulated urination. The results of both modeling and laboratory experiments need validation during a pilot scale experiment in practice. Emissions should be measured on pilot scale as other factors like wind speed, area per cow, farmers management and spatial and temporal varieties of the bedding can influence the ammonia emission to a large extend. Results of both the modeling and the laboratory experiments gave enough reason to continue the project and start a pilot scale experiment.

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