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# THE EFFECT OF DIFFERENT NEW BEDDING MATERIALS ON AMMONIA EMISSION FROM DAIRY COW SLURRY

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## ABSTRACT

Agriculture is the most significant source of Ammonia emission that causes e.g. loss of Nitrogen from agricultural systems. Manure is the main source of Ammonia emissions and causes losses in the nutrient cycles of agriculture as well as local odour nuisance. By using different bedding materials, it is possible to reduce both the Ammonia emissions and to improve the cycling of nutrient. Peat is known as an effective litter material but its use as a virtually non-renewable resource is questionable. Therefore, we need to find new bedding materials to replace peat. In this study, the effect of ten different industrial by-products, reeds and stalks to reduce Ammonia emissions was tested in laboratory in January 2020. Dairy cow slurry and bedding materials were mixed in a volume ratio of 4:1. The Ammonia emission was measured for two weeks once or twice a day. Measurements were performed with a photoacoustic method. The results show that all tested materials reduce the Ammonia emission from the cow slurry used. Interesting new materials to substitute peat are zero fiber and briquetted textile waste. Wheat bran, pellets made of reed canary grass and chopped bulrush had the best effect which is at the same level as that of peat. However, no statistically significant differences between the calculated emission rates were found.

**Keywords:** *Bedding material, Peat, Ammonia emission, Animal production, Cow slurry.*

## INTRODUCTION

Agriculture is the most significant source of Ammonia emission that causes e.g. loss of Nitrogen from agricultural systems. The emission of Ammonia from animal manures is the largest source of atmospheric Ammonia in Europe (Buijsman et al., 1987). Ammonia volatilization from animal husbandry contributes to the total nitrogen deposition, causing acidification and eutrophication. Ammonia emissions cause also losses in the nutrient cycles of agriculture as well as local odour nuisance.

The animal protection law in Finland, legislated in 1996, prescribes that bedding materials have to be used to a greater extend in animal production than previously. Bedding material is essential from the point of view of animal health and welfare. This substrate can be an organic material like wood or plant-based material like straw or inorganic material like clay and sand and should generally be a good absorbent, easily available, comfortable and nontoxic to animals. By using different bedding materials, it is possible to reduce both the Ammonia emissions and to improve the cycling of nutrients.

In Finland, the main bedding materials in use are straw, peat and wood shavings (Alasuutari et al., 2015). Peat is known as an effective litter material to reduce Ammonia emission (Hellstedt et al., 2017) but its use as a virtually non-renewable resource is questionable. Therefore, we need to find new materials with good Ammonia binding capacity to be used as bedding and to replace peat.

## MATERIAL AND METHODS

The effect of different bedding materials on Ammonia emissions was tested on January 2020. The materials were selected based on their available in Finland. The test was made in a laboratory, where the average temperature was 18.6 ˚C (+/- 0.6 ˚C) and the relative humidity was 36 % (+/- 5.0 %), Figure 1.

The properties of the raw materials used in the tests are presented in Table 1. The analyses were made in the laboratory of Natural Resources institute Finland according to standardised methods. Dairy cow slurry and bedding materials were mixed in a volume ratio of 4:1. The ratio was the same as the one used by Airaksinen et al. (2001). Uncovered buckets of 30 litres were filled with 10 litres of slurry and 2.5 litres of bedding materials. The slurry and bedding materials were thoroughly mixed and left standing for one hour before starting the measurements. All the tests were performed in three replicates.

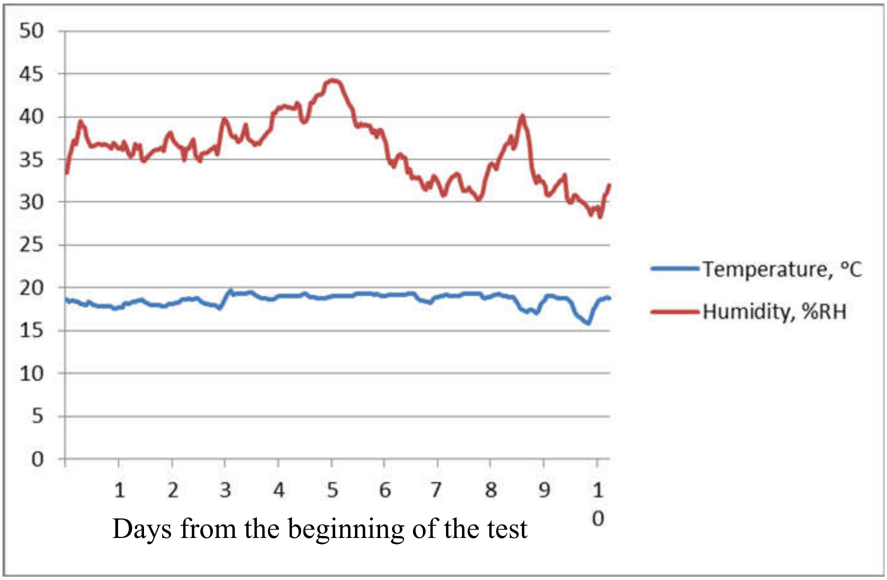


Figure 1. Average temperature and relative humidity during the laboratory test

Table 1. The properties of the materials used in the laboratory test

| | DM | Ammonium-N | Total-N, Kjeldahl | P | pH (the aqueous extract) |
|---|---|---|---|---|---|
| | % | g/kg DM | g/kg DM | g/kg DM | |
| Rapeseed straw | 88.84 | 0.12 | 8.25 | 1.48 | 6.61 |
| Fiber hemp | 90.00 | 0.01 | 4.09 | 0.62 | 5.46 |
| Reed canary grass, pellets | 90.25 | 0.07 | 7.61 | 1.40 | 5.48 |
| Reed canary grass, chopped | 82.86 | 0.53 | 10.37 | 1.38 | 5.65 |
| Common reed, chopped | 84.65 | 0.25 | 6.9 | 0.62 | 5.05 |
| Pelletized sawdust, "Murukuivike" | 89.57 | 0.01 | 0.57 | 0.06 | 5.56 |
| Briquetted textile waste | 96.36 | 0.02 | 1.02 | 0.05 | 7.00 |
| Zero fiber | 42.76 | 0.00 | 0.42 | 0.14 | 9.09 |
| Wheat bran | 88.68 | 0.05 | 28.47 | 13.53 | 6.83 |
| Peat | 58.57 | 0.07 | 8.79 | 0.27 | 3.98 |
| Bulrush | 84.72 | 0.05 | 5.82 | 1.03 | 6.97 |
| Cow slurry | 6.19 | 1.06 | 2.55 | 8.48 | 8.44 |

The amount of Ammonia from the mixtures was measured using a photoacoustic gas analyser (Innova™ Multi-gas analyser). The measuring period was four minutes and there were three replicates of these four-minute periods per one measurement for each material. The results were calculated as mean of these three replicates. The Ammonia emission was measured once for the first day, twice a day for the following three days, and thereafter once a day for five days. From the results, the mean and standard deviation of the three replicates were calculated.The significance of differences was calculated based on 95 % confidence level.

## RESULTS AND DISCUSSION

The results show that all materials tested absorbed Ammonia, and the emissions were lower than that of raw cow slurry. Measured Ammonia emission was larger during the first week and diminished gradually on the second week, Figure 2. This is consistent with Andersson (1996) who also found the emission rates to be lower towards the end of his tests.

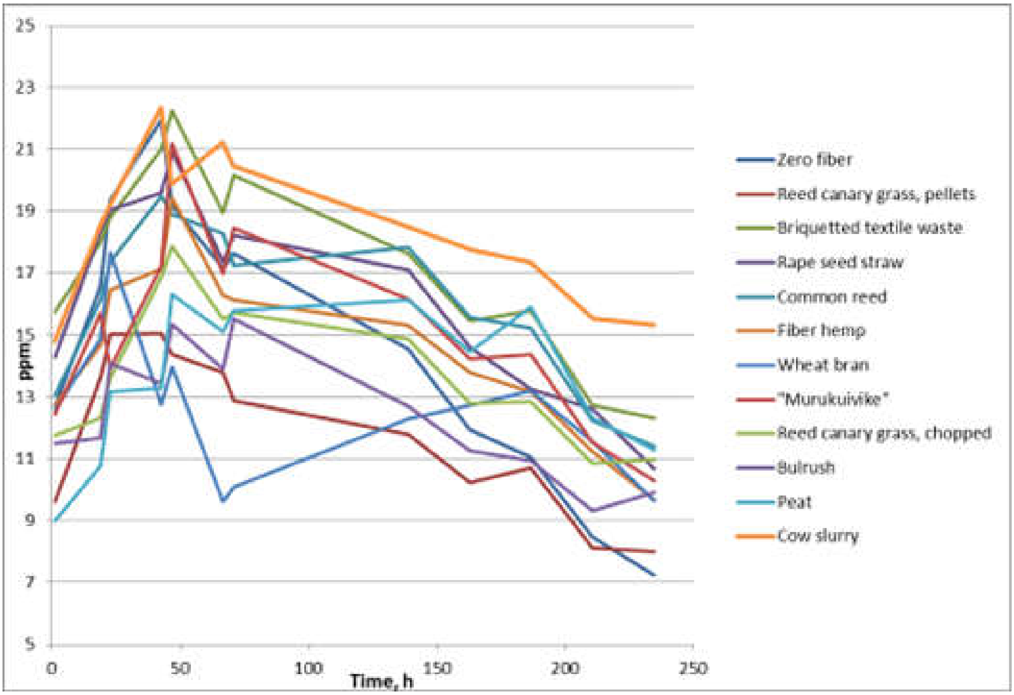


Figure 2. Measured Ammonia emission of the different bedding materials during the test period.

Calculation of the total Ammonia emission ($NH_3$ g/m$^2$) during the whole testing period shows that reed canary grass pellets, bulrush and wheat bran had the best diminishing effect on Ammonia emissions (Figure 30. All of these three had lower Ammonia emission than peat which is considered to be a good material to diminish Ammonia emissions due to its low pH. Materials consisting of chopped straw or stalk had larger Ammonia emissions compared to peat, which is consistent with the results of Jeppsson (1999). According to Andersson (1996) and Airaksinen et al. (2001) shredded newspaper had bigger Ammonia emission as compared to peat. Since zero fiber used in this research is a side product of paper production and there are also paper fibers included in it, our results are parallel. Similar to Airaksinen et al. (2001), we also found the emissions from fiber hemp and saw dust, which is the main component of Murukuivike$^{TM}$, to be larger than those of peat. However, in spite of the discovered differences in the calculated emission rates, none of the differences were statistically significant (Figure 4).

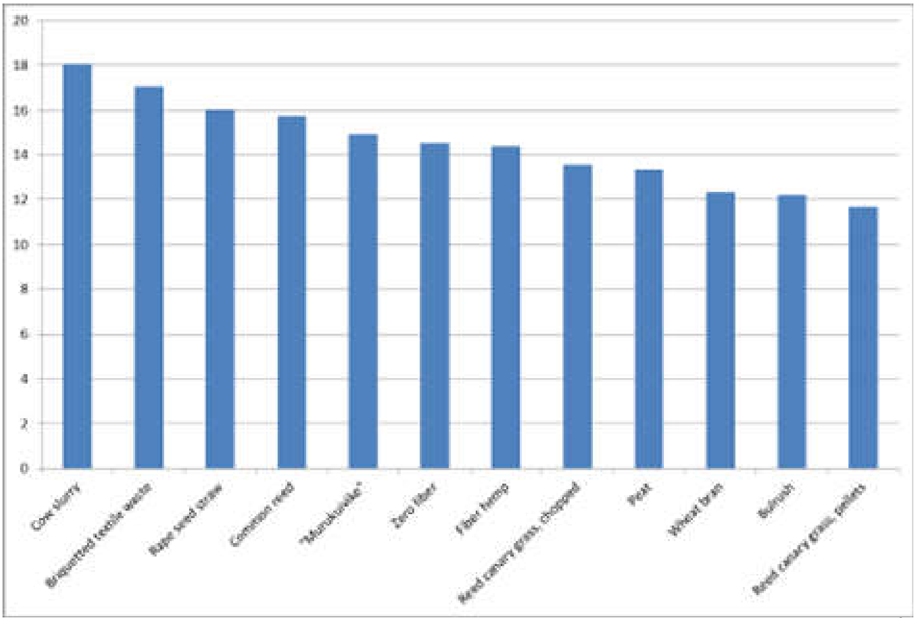


Figure 3. Calculated Ammonia emission during the whole test period, $NH_3$ g/m$^2$

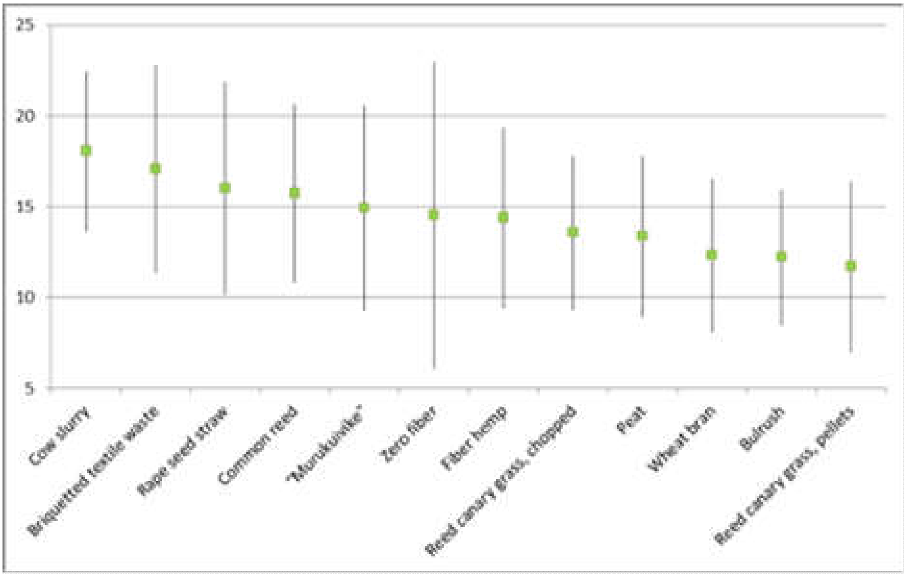


Figure 4. The calculated Ammonia emission results with 95% confidence level.

Changes in total mass and changes in ammonium-N and total-N contents of the slurry-bedding material mixtures during the test period are shown in Figure 5 and Figure 6. For all mixtures, the decrease in mass was less than 10 %. The decrement was highest for wheat bran, 9.6 %, and lowest for briquetted textile waste and bulrush, 6.7 %. For all the other materials the decrease in mass was between 6.8 % and 7.7 %.

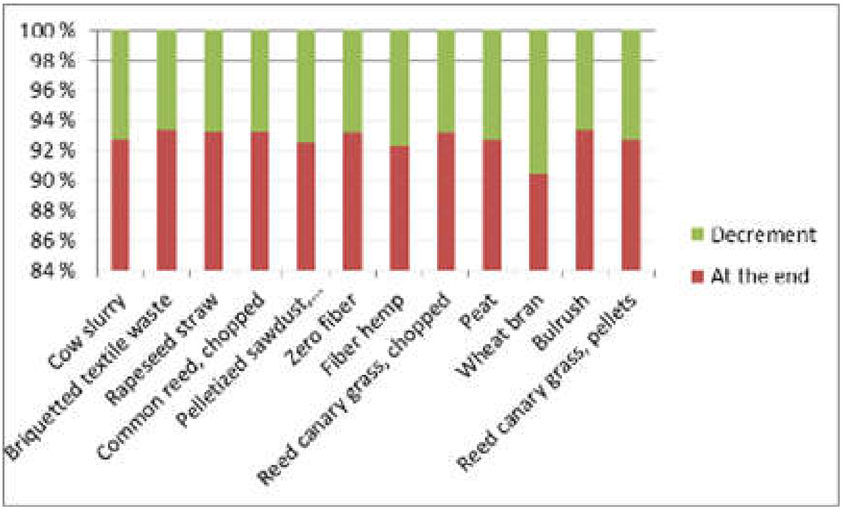


Figure 5. Changes in total mass in the buckets during the test period, as percentage of the initial value.

The decrease in Ammonium-N and total-N contents varied a lot between the materials. For pellets of reed canary grass and for briquettes of textile waste the loss of Ammonium-N was highest, 48 % and 30.6 % respectively. For the other materials the loss varied between 15.2 % and 23.1 %, except for wheat bran in which the amount of ammonium-N was increased by 7.8 % as compared with the value at the beginning of the test. The loss of total-N was highest for bulrush, 12.6 %, common reed, 11.8 %, pelletized sawdust, 11.6 %, zero fiber, 11.4 % and briquetted textile waste, 11.0 %. The loss was lowest for pellets of reed canary grass, 3.9 %, which is at the same level as that of raw cow slurry.

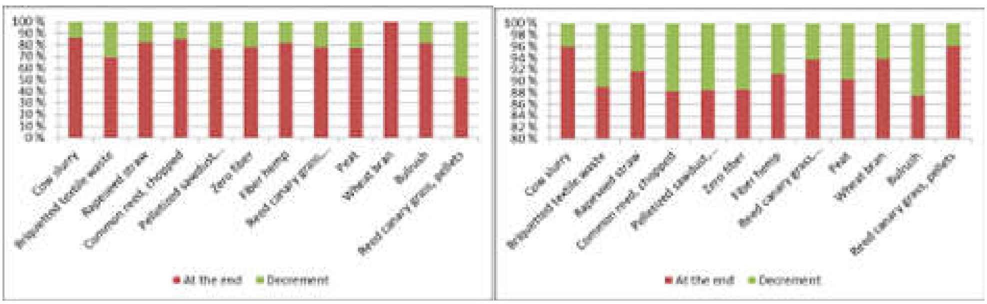


Figure 6. Changes in nutrient content of the slurry mixtures during the test period, as percentage of the initial value. Left Ammonium-N, right Total-N (Kjeldahl method).

## CONCLUSIONS

According to the results, reed canary grass used as pellets or chopped fills the requirements for bedding material replacing peat. Also bulrush and fiber hemp seem to be very suitable for bedding material but their availability is not jet satisfactory. The wheat bran bound Ammonia well but it contains a lot of nutrients, both Nitrogen and Phosphorus. As such, its use as litter for manure is questionable because it would increase the nutrient content of the mixture.

Interesting new materials to substitute peat are zero fiber and briquetted textile waste. The availability of both these materials is good and they are also lacking applications. Before they can be recommended for use as bedding materials more research is needed on farm level.

## REFERENCES

Airaksinen, S., Heinonen-Tanski, H., Heiskanen, M-L. (2001). Quality of different bedding materials and their influence on the compostability of horse manure. Journal of Equine Veterinary Science. March 2001. pp. 125 -130.
DOI: 10.1016/S0737-0806(01)70108-6

Alasuutari, S., Palva, R., Hellstedt, M., Kivinen, T., Louhelainen, K., Mäittälä, J. (2015). Kuivitusopas. [Guide to Bedding]. Maito ja Me 27/1. 23 p.

Andersson, M. (1996). Performance of Bedding Materials in Affectiong Ammonia Emissions from Pig Manure. Journal of agricultural Enginering Research 65. pp. 213-222.

Buijsman, E., Maas, J.F., Asman, W.A.H. 1987. Antropogenic $NH_3$ emission in Europe. Atmospheric environment 21. pp. 1009-1022.

Hellstedt, M., Luostarinen, S., Regina, K., Särkijärvi, S., Grönroos, J., Haapala, H. (2017). Lypsykarjanavetoiden ammoniakkipäästöjen nykytaso ja vähentämismenetelmät. [Current levels of ammonia emissions from dairy cattle and methods for reducing them] Luonnonvara- ja biotalouden tutkimus 53/2017.Luonnonvarakeskus. Helsinki. 64 p.

Jeppsson, K-H. (1999) Volatilization of Ammonia in Deep-litter Systems with Different Bedding Materials for Young Cattle. Journal of agricultural Enginering Research 73. pp. 49-57.