REPORT

ON MEASURES AND TECHNIQUES OF MANURE STORAGES AND HANDLING AT THE EXPERIMENTAL STATION AND PILOT FARM FOR EMISSIONS

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This report is part of WP 2 Task 2.1.2 Study and monitor manure storages and innovative handling techniques.

The report focuses on measures and methods aimed at reducing emissions related to manure storage and handling, specifically through research conducted at experimental station and pilot farm. It provides an overview of various tools and techniques that have been tested and implemented in these specific environments. The report covers topics such as manure acidification, the utilization of microorganism additives, and the application of natural sorbents. Additionally, it discusses the potential benefits and challenges associated with each approach. By examining the experiences and results obtained from these experimental station and pilot farm, the report aims to contribute to the existing knowledge base and provide valuable insights for future efforts in reducing emissions associated with manure storage and management.

INTRODUCTION

Animal production, particularly inadequate manure management, is responsible for a significant quantity of NH_3 and GHG emissions at a global scale. Gaseous emissions occur throughout all stages of manure management, including housing, storage, processing, and recycling as crop fertilizer after field application. Available solutions involve the use of low-emission equipment, good agricultural practice and utilizing different additives.

Emissions during manure storage result from complex biological, physical, and chemical processes. One promising approach to reducing NH_3 and CH_4 emissions is manipulating the balance between ammonia and ammonium by lowering the pH of the manure. Under acidic or neutral pH conditions, nitrogen in manure is converted to NH_4, while at higher pH levels, it becomes ammonia (NH_3). By reducing emissions from manure, we can not only protect the environment, but also preserve nutrients in the manure and increase the fertilizing value of the manure for plants.

To ensure the most efficient solution for manure management, it is important to assess the effects of slurry treatments and combinations of different techniques. This assessment should aim to avoid pollution swapping and identify the most effective measures and methods for reducing GHG and ammonia emissions from manure management systems. The main purpose of this task was to evaluate the effectiveness of various measures and innovative techniques in reducing GHG and ammonia gas emissions from manure management systems.

METHODOLOGY

The studies to evaluate the impact of manure acidification, the use of probiotics, and different sorbents on emissions of polluting gases from manure was conducted under **laboratory conditions** (in the climate-controlled chambers) at the experimental base of the Animal Science Institute of LSMU, using liquid cattle manure which was homogenized and placed into 90-liter capacity containers (Fig. 1).

Figure 1. Manure containers

In study of manure acidification in the control container, the manure was stored without any additives, whereas in the tested container, the manure was acidified to pH5 and pH7. Gas concentrations were measured using the passive chamber method as described by Matulaitis (2014).

Gas Emission Rate was calculated using the following formula:

$$F= V\ M\ p\ (C_1\text{-}C_0)/R\ (T+273)\ A\ l\ h$$

where, F (mg/(m^2 l h)) – gas emission rate; V (m^3) – headspase capacity in the chamber; M (g/mol) – gas molar mass; p (kPa) – gas pressure; C_1 (ppm) – gas concentration in the chamber at the fifth minute of measurement; C_0 (ppm) – gas concentration in the chamber at the beginning of measurement; R (8.314 J/K · mol) – gas constanta; T (^{o}C) – gas temperature; A (m^2) – the surface area of manure; l (l) – the amount of manure; h (0,08 h) – the duration of gas measuring period.

Gas concentrations were measured using gas analysers equipped with electrochemical and infrared sensors and laser methane detector.

A microbiological additive consisting of *Bacillus subtilis varnatto, Bifidobacterium animalis, Bifidobacterium bifidum, Bifidobacterium longum, Lactobacillus acidophilus, Lactobacillus buchneri, Lactobacillus bulgaricus, Lactobacillus casei, Lactobacillus delbrueckii, Lactobacillus fermentum, Lactobacillus plantarum, Lactococcus lactis, Lactococcus lactis subsp. Diacetylactis, Rhodopseudomonas palustris, Rhodopseumonas sphaeroides, Saccharomyces cerevisiae, Streptococcus thermophilus*, along with molasses, sea salt, rice bran, various minerals, algae, and a mixture of various plants was used to evaluate the influence of microbiological additives on emissions.

Microbiological additives were applied to liquid cattle manure by adding 20 ml microbiological additive per container at the beginning of the study and repeatedly on days 6, 14 and 20. The manure was stored in climate control chambers in open containers, using three temperature regimes - 5, 15 and 25 C.

In order to evaluate the influence of **natural sorbents** on gas emissions from cattle manure, sorbents such as biochar, peat, and dolomite were tested (Fig. 2). The emissions of manure treated with these sorbents were compared with the emissions of untreated manure.

Figure 2. Sorbents: a-biochar, b-peat, c- dolomite

Field trials were conducted to determine the impact of acidified cattle slurry on crop yield. The study involved applying acidified cattle slurry to specific plots of land and comparing the resulting crop yields with those from control plots where regular cattle slurry and traditional fertilization with mineral fertilizers was used. The data collected from these field tests aimed to provide insights into the potential benefits or drawbacks of using acidified cattle manure as a fertilizer for crop production**.** The aim of this study was to evaluate the impact of acidified slurry on grain yield and its quality by using an innovative technique SATs (in-field).

Figure 3. Slurry acidification tehniques *in-field* (SATs)

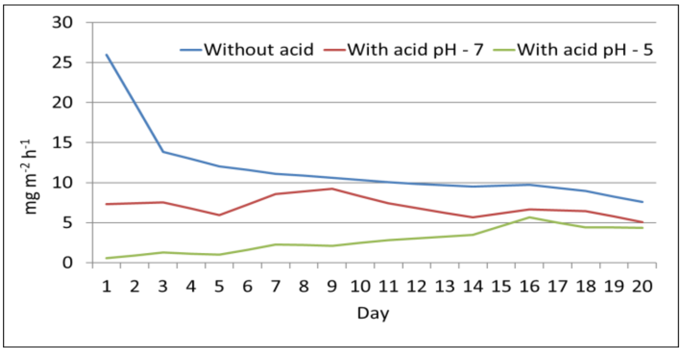
The technique involved the addition of H_2SO_4 to the slurry during the fertilization process in the field, as shown in Figure 3. Both acidified and non-acidified cattle slurries were applied to barley and spring wheat fields for evaluation. In comparison, control fields were fertilized using mineral fertilizer NPK 20-10-10. The slurry was acidified to a target pH value of 6.0.

RESULTS

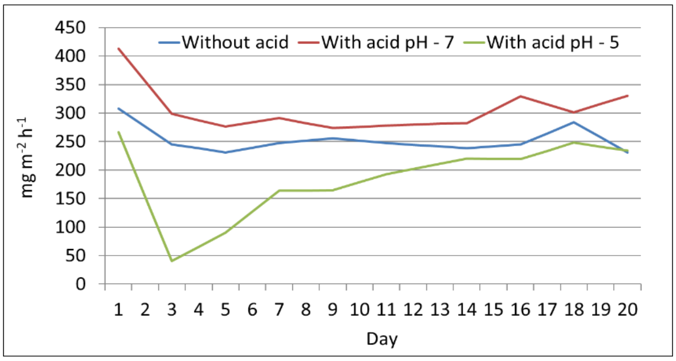
Assessment of cattle manure acidification effects on GHG and ammonia emissions and crop yield.

Studies aimed at evaluating the influence of manure acidification on the emission of polluting gases from manure have shown that after acidifying the manure to pH7, NH_3 emissions decreased by 39.6% and CH_4 by 29.5%. Even better results were obtained when the manure was acidified to pH5, reducing NH_3

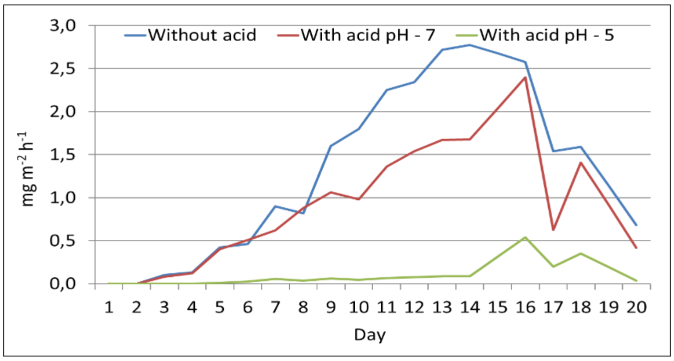
emissions by 75.6% and CH_4 by 91.8%. However, it was observed that CO_2 emission was 22.2% higher when the manure pH was 7, although it remained 27.8% lower when the pH value was 5 (Fig. 4).



NH_3



CO_2



CH_4

Figure 4. Effect of acidification on gas emission rates from cattle liquid manure

The highest emission values of ammonia and carbon dioxide during storage of manure were observed in the first week, then they gradually decreased and were insignificant at the end of the study. The largest differences in emissions between different acidification levels were also found in the first week, after which these differences became insignificant.

Study of the effect of acidified cattle slurry on crop yield.

Field tests on the effect of acidified slurry on crop yield have shown positive results (Table 1). Fertilizing fields with acidified cattle manure led to a 13.1% higher barley yield and a 3.43% higher protein content compared to fields fertilized with untreated slurry. Additionally, compared to barley grown in fields fertilized with mineral fertilizers, the yield and protein content were 14.1% higher and 9.15% higher, respectively.

Table 1. The influence of different fertilization methods on the crop yield and quality

Crops	**Treatment**	**Grain yield, t/ha**	**Moisture content, at harvest time, %**	**Protein in DM, %**
Barley	Mineral fertilizers (NPK 20-10-10)	4,26	13,5	10,32
	Untreated slurry	4,31	12,9	10,97
	Acidified slurry	4,96	13,9	11,36
spring wheat	Mineral fertilizers (NPK 20-10-10)	4,87	13,7	15,89
	Untreated slurry	4,93	12,8	15,95
	Acidified slurry	5,12	13,2	16,02

Smaller differences were observed in spring wheat fields, where acidified slurry resulted in a 3.7% and 4.9% higher yield compared to fields fertilized with untreated slurry and mineral fertilizers, respectively (Table 1).

In conclusion, mild acidification of cattle slurry during soil application can effectively reduce NH_3, CO_2, and CH_4 emissions while improving the fertilizing value of the manure, providing a successful solution for farmers.

Assessment of the influence of microbiological additives on the emission of polluting gases from cattle manure

The study with microbiological additive of *Bacillus subtilis varnatto, Bifidobacterium animalis, Bifidobacterium bifidum, Bifidobacterium longum, Lactobacillus acidophilus, Lactobacillus buchneri, Lactobacillus bulgaricus, Lactobacillus casei, Lactobacillus delbrueckii, Lactobacillus fermentum, Lactobacillus plantarum, Lactococcus lactis, Lactococcus lactis subsp. Diacetylactis, Rhodopseudomonas palustris, Rhodopseumonas sphaeroides, Saccharomyces cerevisiae, Streptococcus thermophilus*, along with molasses, sea salt, rice bran, various minerals, algae, and a mixture of various plant showed that microbiological additives did not have a statistically significant effect on manure composition indicators but contributed to the reduction of ammonia emissions (Fig. 5).

During the seven-day period, the microbiological additive had a positive effect on the reduction of ammonia emissions. The difference in emission between manures of different groups was 3.8 - 3.9 g m-2 d -

1 and it was found that at all manure storage temperatures, ammonia emission from cattle manure reached its peak on day 4-8 of storage.

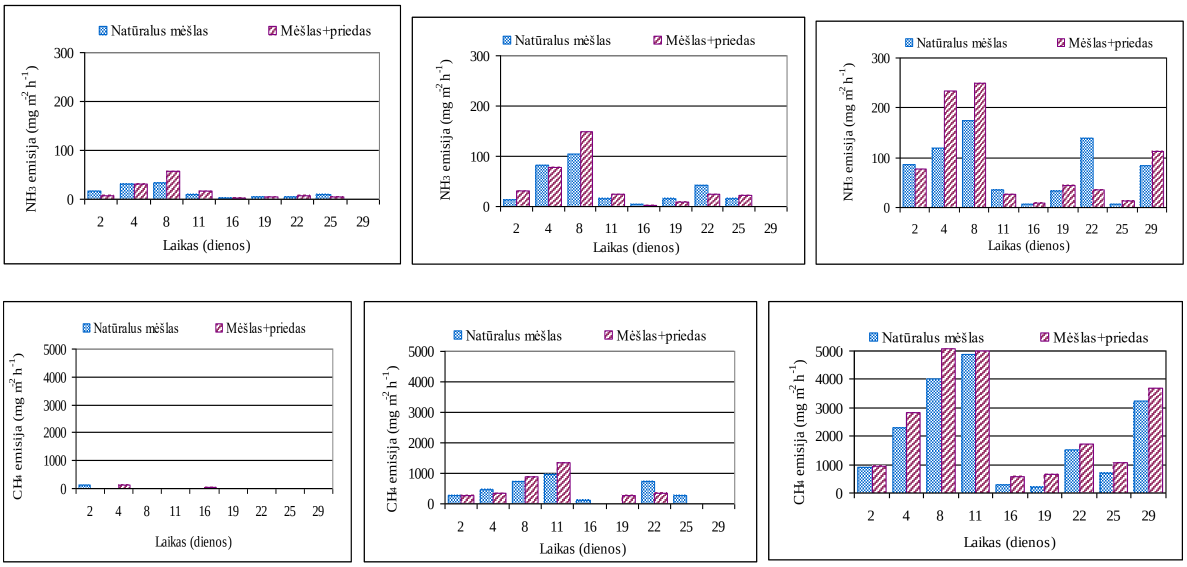


Figure 5. Influence of microbiological additive on gas emissions at different ambient temperatures

Comparing cattle manure with and without a microbiological additive at the same temperatures, the average intensity of NH_3 emission was found to be 2.4 and 5.4 times higher, respectively. Methane emissions were negligible at a storage temperature of 5°C but increased significantly at 15°C and 25°C, with the highest intensity observed between 8-11 days and 25-29 days. The average intensity of CH_4 emission from cattle manure ranged from 13.92 to 2038.17 mg m-2 h-1. Comparatively, CH_4 emission from manure without additives stored at 5°C and 25°C was 1.5 and 1.2 times lower, respectively, than from manure with additives.

Certain differences were determined between the method of introduction of the microbiological additive when it was sprayed on the manure surface, mixed in, or sprayed in the barn. Here, the microbiological additive was most effective for emission reduction when it was sprayed on the manure surface.

Impact of natural sorbent application on NH_3, CO_2 and CH_4 gas emissions from dairy cattle manure

Conducted study to evaluate the effectiveness of natural sorbents such as biochar, peat, and dolomite in reducing ammonia and greenhouse gas emissions from liquid cattle manure showed that the most effective means of reducing carbon dioxide and ammonia gas emissions was biochar. Addition of 10% biochar to liquid cattle manure reduced ammonia emission by 14.5% and carbon dioxide by 21.7% during the first three days (Fig. 6). Meanwhile, dolomite powder increased carbon dioxide emission by 38.3% compared to the control group without sorbents. Peat was also ineffective in reducing emissions, with emissions from containers in this group being nearly the same as those from the control group without sorbents. Studies of methane gas concentrations (Fig. 7) showed that methane emissions were very low at the beginning of the study, but gradually increased during manure storage. However, methane emissions from the peat group containers at the end of the study decreased by 42.3% compared to the beginning of the study.

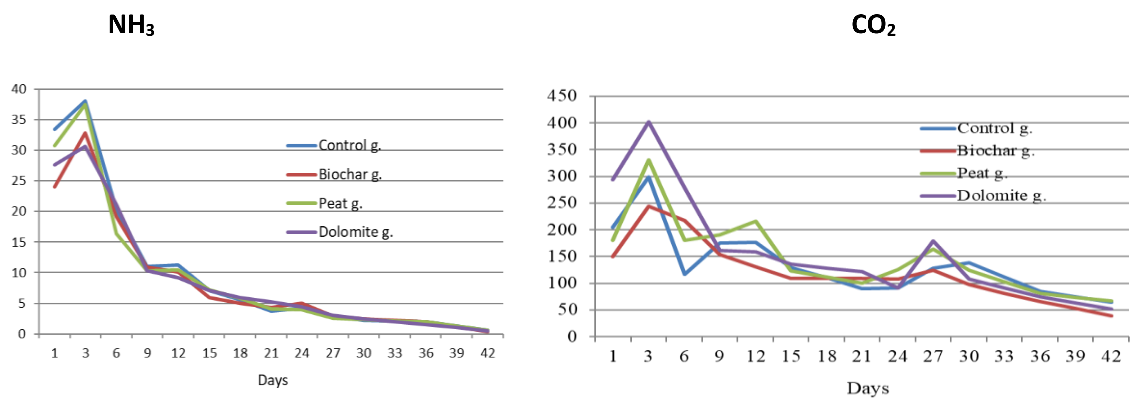


Figure 6. Treatment effects on NH_3 and CO_2 gas emission rate fluxes from liquid cattle manure, mg/m2/h

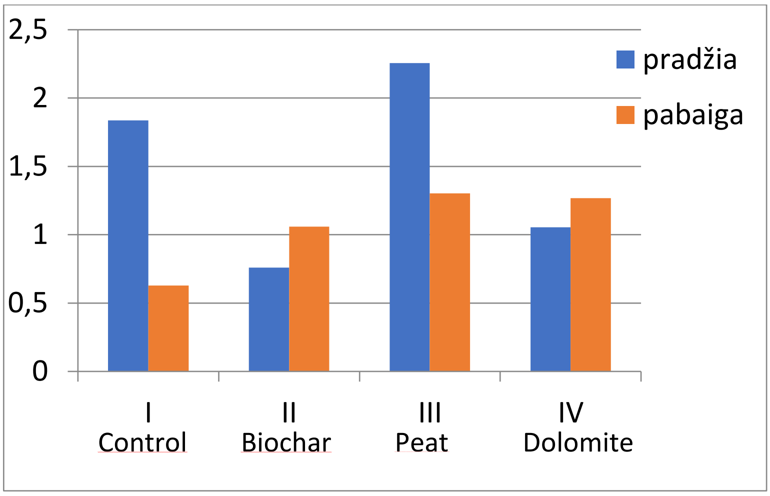


Figure 7. Treatment effects on methane gas emission rate from liquid cattle manure, mg/m2/h

At the beginning of the study, biochar and dolomite flour reduced methane emissions by as much as 59 and 43%, respectively, at the end of the study, all used sorbents increased methane emissions compared to the control group without sorbents.

In conclusion, it can be stated that the ability of natural sorbents to reduce GHG and ammonia gas release from liquid cow manure is not very high, perhaps due to the specific property of cattle manure to form a natural crust during longer storage.

CONCLUSIONS

This study highlights the importance of proper management of manure systems, as only such management practices can lead to efficient, and low-emission production. Although significant progress has been made in managing manure systems, we have to admit that further efforts are needed to reduce current emissions to meet ambitious climate change and ammonia reduction targets and to achieve more sustainable and environmentally friendly practices in manure management.

Summarizing the conducted research and the obtained results, it can be stated that the use of manure acidification, microbiological additives and sorbents in manure management systems can help reduce GHG and ammonia gas emissions. The most effective is manure acidification. After acidifying the manure to pH7, positive results were already obtained: ammonia emission decreased by 39.6%, methane by 29.5%. A higher level of manure acidification to pH5 gave really good emission reduction results, reducing ammonia gas emissions by as much as 75.6% and methane gas emissions by 91.8%. In addition, acidification of cattle manure can help not only to reduce emissions, but also to improve the fertilizing value of the manure. Meanwhile, the ability of natural sorbents to reduce GHG and ammonia gas emissions from liquid cow manure is not very high. It is possible that this was influenced by the specific property of cattle manure to form a natural crust during manure storage.

Although some results have been achieved, further research and evaluation is still needed to investigate and evaluate different measures and newly developed techniques and determine which ones can effectively contribute to reducing emissions. This ongoing research and evaluation will lead to better understanding and implementation of strategies to reduce gas emissions from cattle manure.

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