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# IMPACT OF SORBENT APPLICATION ON $\text{NH}_3$ , $\text{CO}_2$ AND $\text{CH}_4$ GAS EMISSIONS FROM DAIRY CATTLE MANURE

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# INTRODUCTION

- ✓ Farm livestock manure, especially liquid manure is an important source of  $\text{NH}_3$  and Greenhouse gases. Emissions that occur during manure storage are the result of complex various biological, physical, and chemical transformation processes. Methane emissions during manure storage can represent up to  $6.5 \text{ kg m}^{-2}$ . Therefore, reducing emissions from manure is important for the protection of the environment and also for nutrient preservation in manure.  $\text{NH}_3$  and Greenhouse gas emissions vary depending on environmental conditions, type of management and composition of the manure.
- ✓ Research on emissions from liquid manure has been generally focused on the influence of mitigation strategies such as covers (Amon et al 2006, Chadwick 2005, Lague et al 2005), strong acids (such as  $\text{H}_2\text{SO}_4$ ) (Im, Petersen, Lee, Keem, 2020) and nitrification inhibitors (e.g., N-(n-butyl) thiophosphoric triamide (NBPT), 3,4-dimethylpyrazol phosphate (DMPP), and dicyandiamide (DCD). Researchers have explored the effects of addition of sawdust, straw and phosphogypsum and various manure additives (Luo et al., 2013, Wu et al., 2019, Tubail et al., 2013, Maurer et al., 2017, Mao et al., 2019, Yin, Y., et al, 2021, Wang et al., 2018, Awasthi et al., 2016, Eunjong, et al., 2018), but the results of these measures are highly variable and the knowledge of their effects on manure is lacking.
- ✓ In addition, strong chemical compounds and materials may not always be environmentally friendly and can cost a lot of money. Therefore, many countries are looking for ways to use natural more environmentally friendly materials that would be effective and help reduce emissions.



**The AIM** of our study was to evaluate the effectiveness of natural sorbents (biochar/coal, peat, dolomite) on ammonia and GHG emissions from liquid cattle manure



The study was conducted as part of project „**Climate Care Cattle Farming**“ tasks contributing to „Study and monitor manure storages and innovative handling techniques“

# MATERIALS AND METHODS

The study was conducted on laboratory scale at LUHS Animal Science Institute.

Fresh liquid cow manure was immediately delivered to the laboratory, homogenized and placed into 90 liter capacity containers with 7 liters of manure per container and 4 replicates per each group. The manure was stored for 42 days.

Gas emissions were measured using passive chamber method.

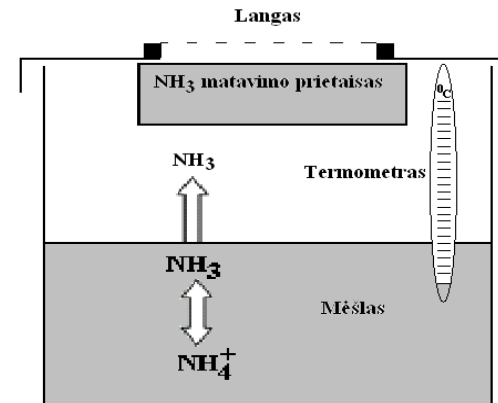
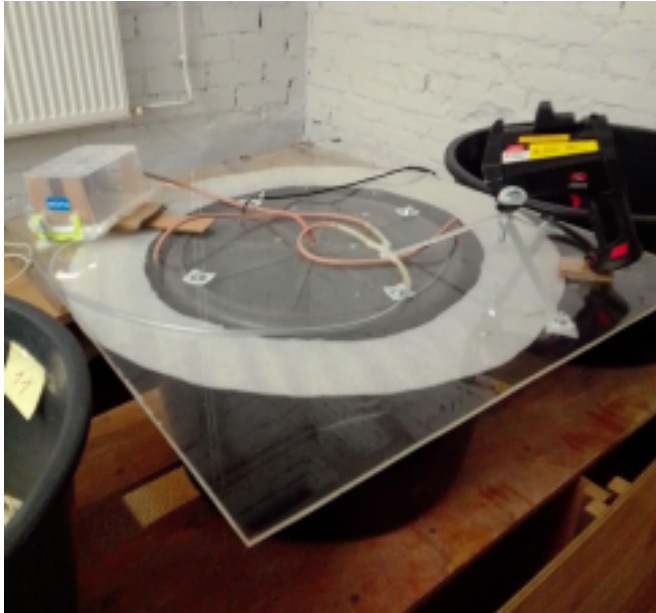
Three treatments (10% sorbents calculated on the dry matter) were added to manure:

- Group 1— Control group without sorbents;
- Group 2 — Biochar (coal) 5-9 mm fraction;
- Group 3 — Peat (pH 4);
- Group 4 — Dolomite (5-9 mm fraction);



# PASSIVE CHAMBER METHOD

## *(Gas Concentration Analyses)*



## Calculation of Gas Emission Rate

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

$F$  (mg/(m<sup>2</sup> l h)) – gas emission rate;  $V$  (m<sup>3</sup>) – headspace 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 constant;  $T$  (°C) – gas temperature;  $A$  (m<sup>2</sup>) – the surface area of manure;  $l$  (l) – the amount of manure;  $h$  (0,08 h) – the extension of gas measuring period.



### ***Manure Composition Analyses***

Total nitrogen content (TN) was analyzed by the Kjeldahl method (Peters (ed.) et al., 2003);

Ammonium nitrogen ( $\text{NH}^+3\text{-N}$ ) – by distillation and a device FOSS Tecator™ (Denmark) apparatus.

Quantitative pH analysis – by pH meter HI 98128, HANNA instruments, USA).

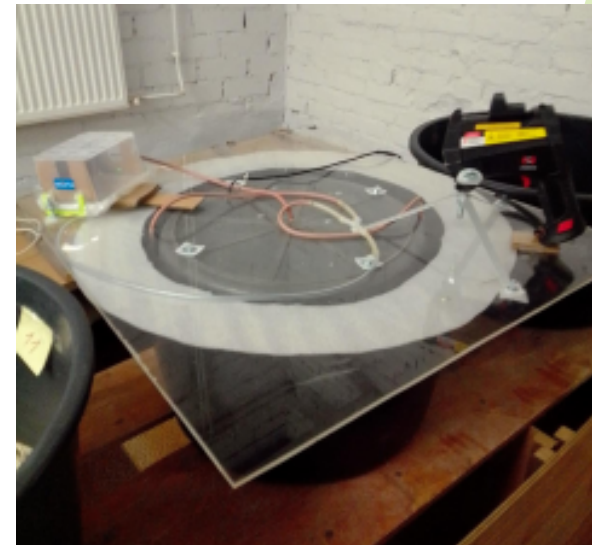
### ***Gas Concentration Analyses***

$\text{NH}_3$ ,  $\text{CH}_4$  and  $\text{CO}_2$  concentration were measured after adding the sorbents on the following day, which was the first day of measurement, and then every 3 days for the entire 6 weeks of the experiment with 3 replicates for each test in hermetically closed chambers with installed gas analyzers Dräger Pac III M40 (Keison Products, England), Almemo 2890-9 (Ahlborn Mess- und Regelungstechnik GmbH, Germany) and handheld remote laser methane detector (LMD) for  $\text{CH}_4$  analyses.

### ***Statistical Analyses***

Statistical analyses were performed using statistical software package STATISTICA (Version 7; Stat Soft Inc. Tulsa, OK, USA). The differences were considered to be statistically significant at  $P \leq 0.05$ .

# RESULTS

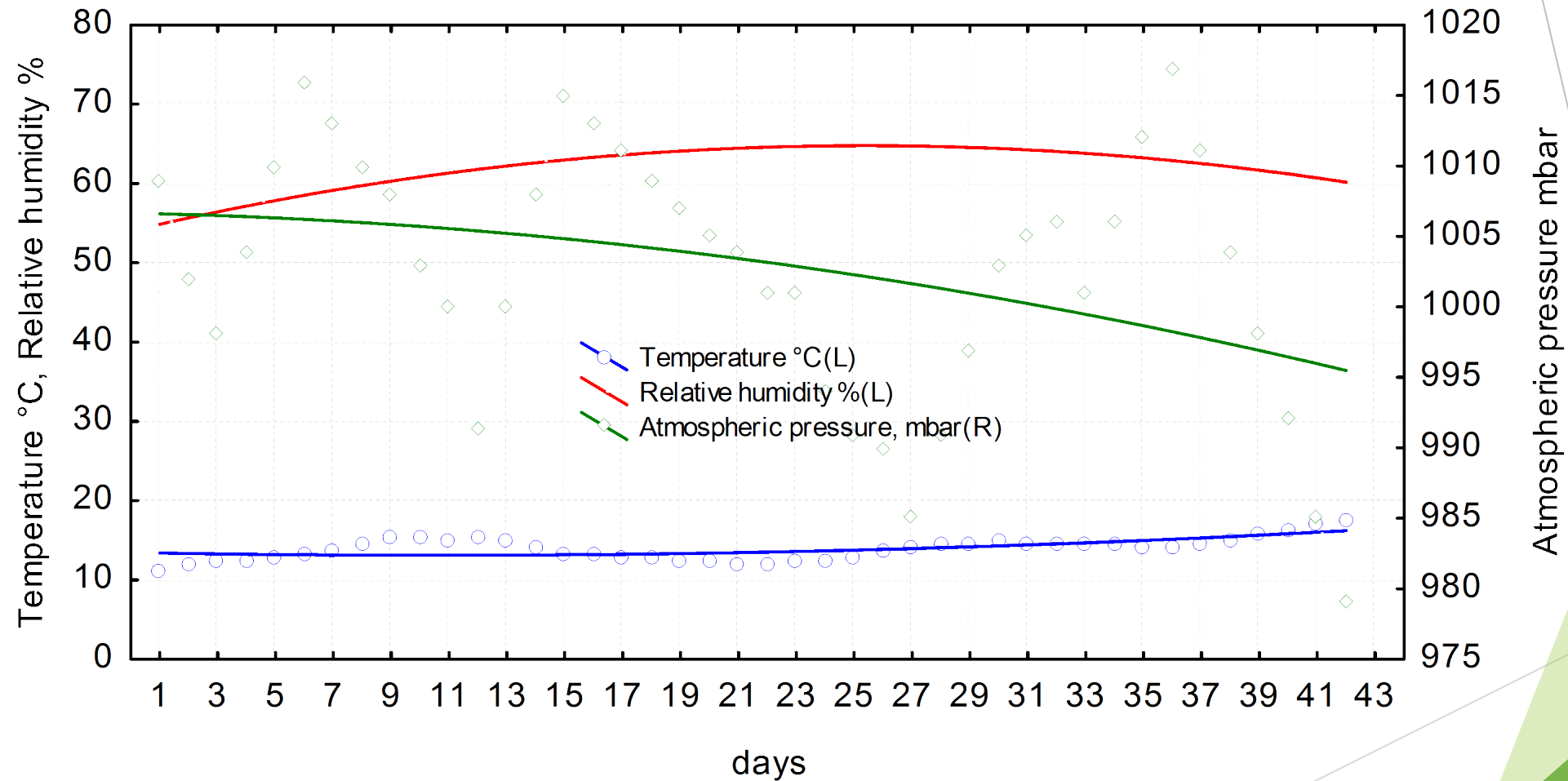


# Characteristics of manure after adding sorbents

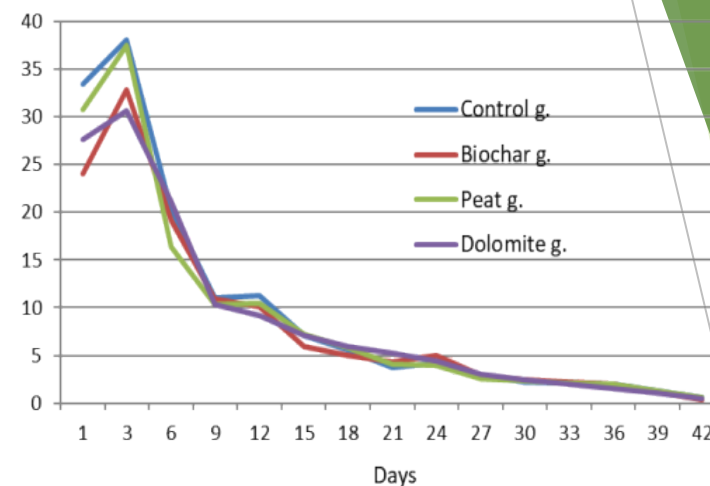
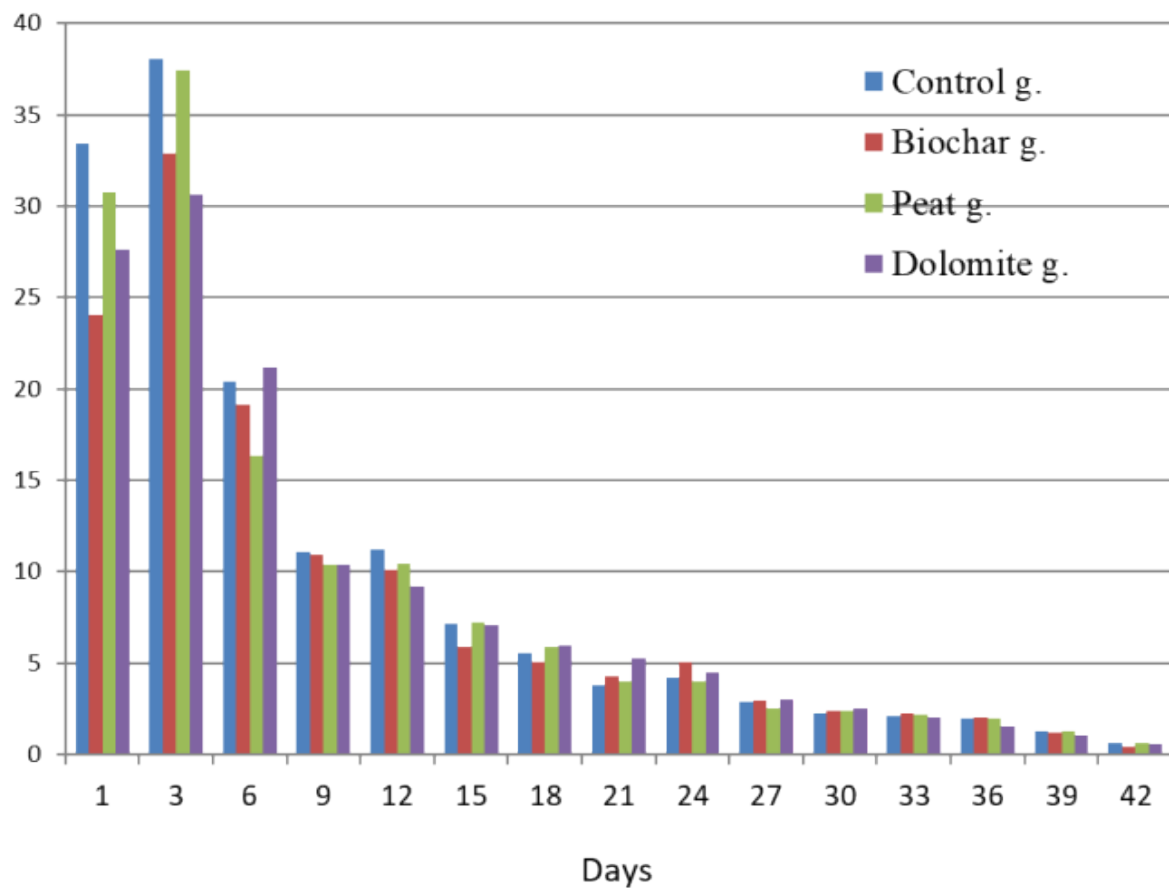
Item	Without sorbents		Biochar		Peat		Dolomite	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
<b>DM, %</b>	9.9	0.08	11.6	0.22	10.9	0.09	10.8	0.45
<b>Ash, %</b>	2.1	0.03	2.1	0.04	2.1	0.01	2.4	0.13
<b>pH, %</b>	8.6	0.22	8.6	0.02	8.3	0.03	8.5	0.01
<b>KN,%</b>	3.2	0.33	3.2	0.17	3.3	0.22	3.3	0.11
<b>NH<sub>3</sub>-N mg, %</b>	320.9	21.5	258.00	20.55	269.8	6.93	260.9	7.29



# Environmental parameters during the experiment



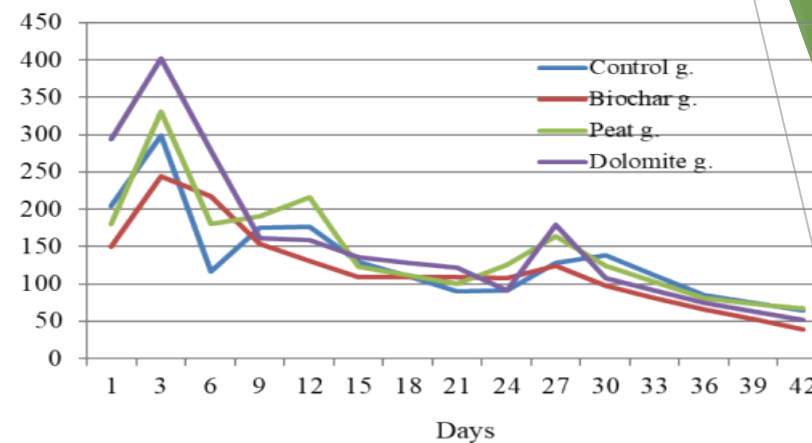
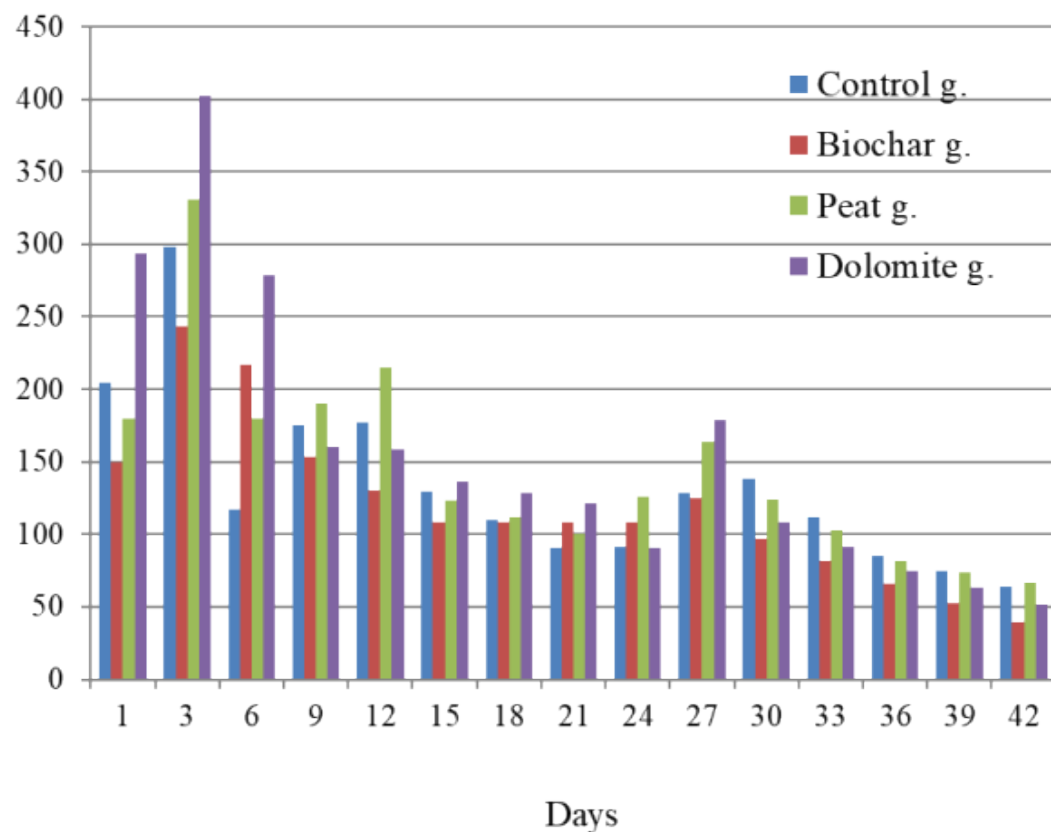
# Treatment effects on NH<sub>3</sub> gas emission fluxes from liquid cattle manure during short-term storage, mg/m<sub>2</sub>/h



## NH<sub>3</sub> production from cattle manure during the study period

Group	Cumulative NH <sub>3</sub> production, kg/m <sup>2</sup>	Average per day, g/m <sup>2</sup>
Control	0.39	9,36
Biochar	0.37	8,78
Peat	0.40	9,43
Dolomite	0.39	9,27

# Treatment effects on CO<sub>2</sub> gas emission rate fluxes from liquid cattle manure during short-term storage, mg/m<sub>2</sub>/h

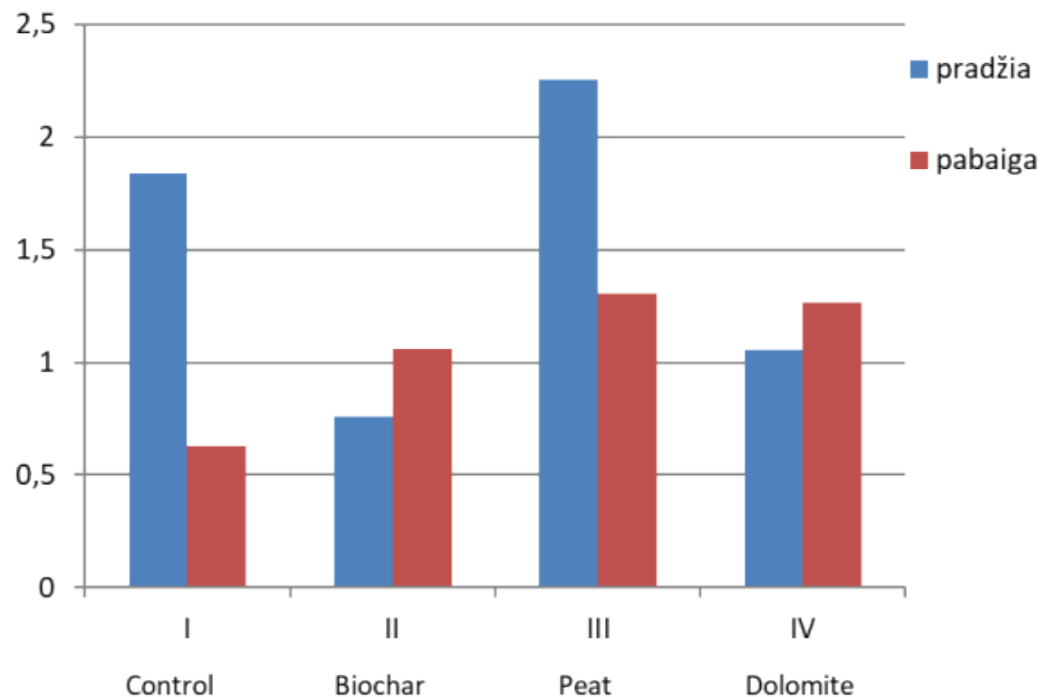


## CO<sub>2</sub> production from cattle manure during the study period

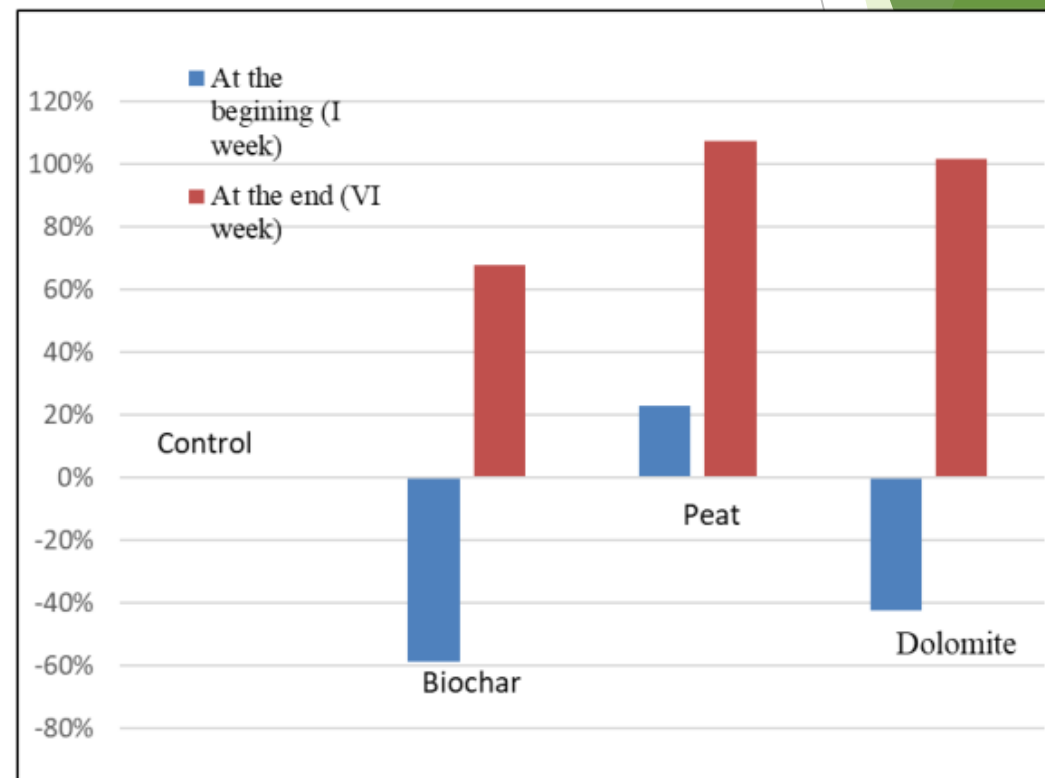
Group	Cumulative CO <sub>2</sub> production, kg/m <sup>2</sup>	Average per day, g/m <sup>2</sup>
Control	3.94	93,92
Biochar	3.79	90,20
Peat	4.51	107,38
Dolomite	4.99	118,90



## Influence of sorbents on CH<sub>4</sub> concentration (mg/m<sub>3</sub>) during short-term storage of liquid cattle manure



## CH<sub>4</sub> emission from manure compared to the control group without sorbents



# CONCLUSIONS

The results of this laboratory study indicated that the highest emission values of ammonia and carbon dioxide during short-term storage of manure in all groups 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 groups were also found in the first week, after which these differences became insignificant..

The most effective at reducing emission was biochar. Addition of 10% biochar to liquid cattle manure reduced ammonia emissions by 14.5 ( $P<0.05$ ), and carbon dioxide by 21,7 % ( $P<0.05$ ) in the first three days, while using dolomite flour carbon dioxide emission increased by 38.3% ( $P<0.02$ ) compared to the control group without sorbent. Peat was also ineffective in reducing emissions, with emissions almost the same as in the control group without sorbent.

However, methane emission from manure was found to be higher at the end of the study than at the beginning, except for the peat group, where at the end the emission was found to be 42.3% lower compared to the emission in the 1st week. Biochar and dolomite groups, compared to the control group without sorbents, reduced methane emissions by 59 and 43%, respectively, in the first week of the study, but at the end of the study all used sorbents increased methane emissions from manure compared to manure without sorbents. During the entire study period, biochar reduced the total emission by 6.9 percent, while peat and dolomite increased it compared to the control group without sorbents.

In summary it can be stated that the ability of natural sorbents to reduce gas emissions from liquid cow manure is not high, perhaps due to the specific property of cattle manure to form a natural crust during storage.



# THANK YOU FOR YOUR ATTENTION!

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