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IMPACT OF SORBENT APPLICATION ON NH_3, CO_2 AND CH_4 GAS EMISSIONS FROM DAIRY CATTLE MANURE

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INTRODUCTION

- ✓ Farm livestock manure, especialy liquid manure is an important source of NH_3 and Greenhouse gases. Emissions that ocur during manure storage are the result of omplex various biologoval. Physical, and chemical transformation processes. Methane emissionns during manure storage can represent up to 6.5 kg m^{-2}. Therefore, reducing emissions from manure is important for the protection of the environment and also for nutrient preservation in manure. 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 beengenerally focused on the influence of mitigation strategies such as covers (Amon et al 2006, Chadwick 2005, Lague et al 2005), strong acids (such as H_2SO_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“

MATHERIALS 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.

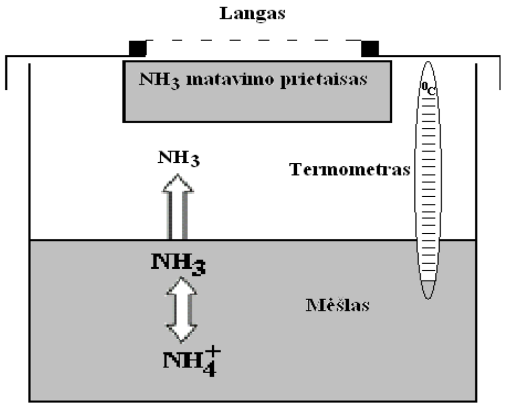
Gas emissions were measured using passive chamber method.

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

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

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

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

Gas Concentration Analyses

NH_3 CH_4 and 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 CH_4 analyses.

Statistical Analyses

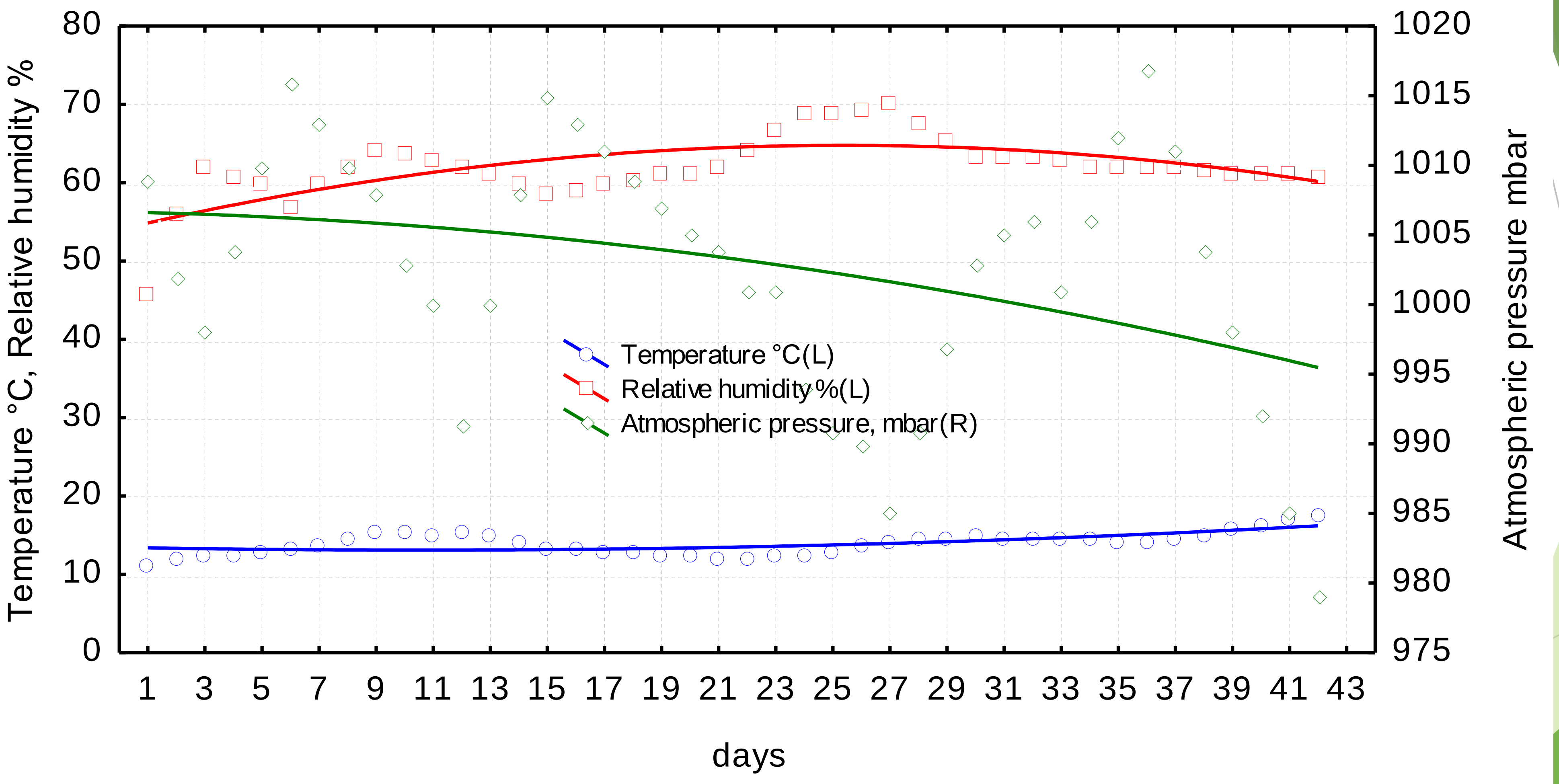
Statistical analyses were performed using statistical software package STATISTICA (Version 7; Stat Soft Inc. Tulsa, OK, USA). The differences were considered to be statistically significant at $P \leq 0.05$.

RESULTS

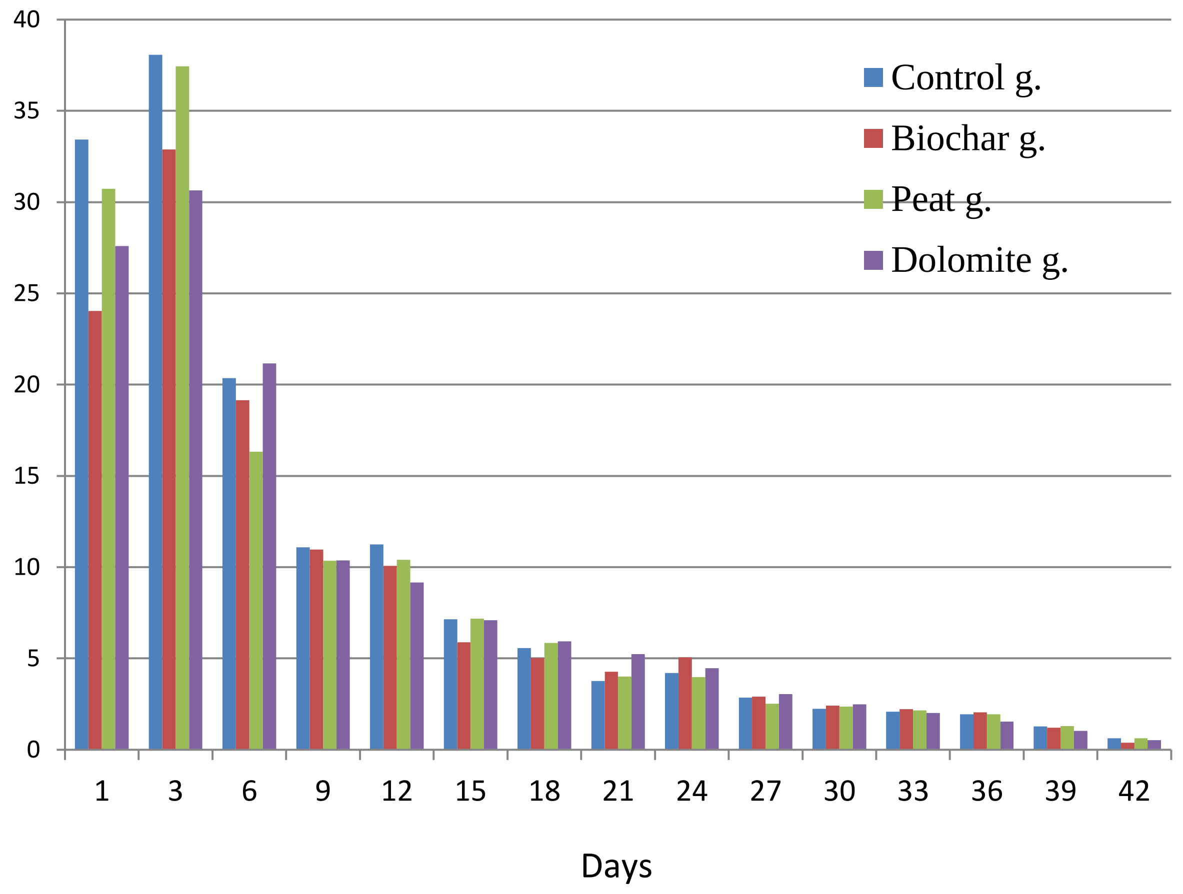
Characteristics of manure **after adding sorbents**

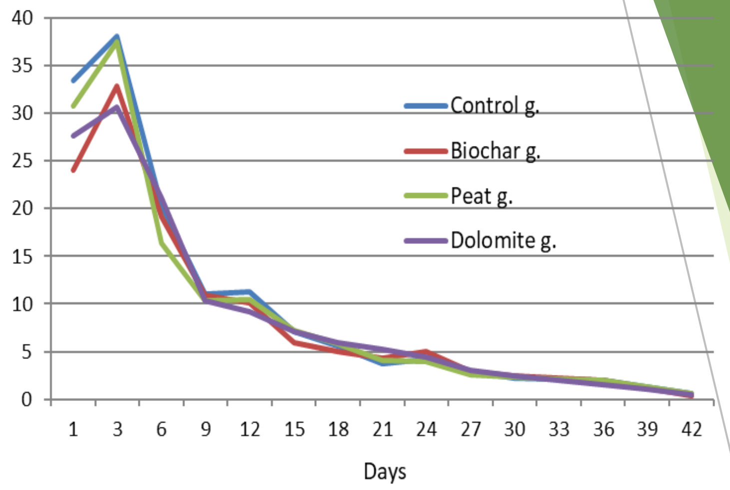
Item	**Without sorbents**		**Biochar**		**Peat**		**Dolomite**	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
DM, %	9.9	0.08	11.6	0.22	10.9	0.09	10.8	0.45
Ash, %	2.1	0.03	2.1	0.04	2.1	0.01	2.4	0.13
pH, %	8.6	0.22	8.6	0.02	8.3	0.03	8.5	0.01
KN,%	3.2	0.33	3.2	0.17	3.3	0.22	3.3	0.11
NH_3-N mg, %	320.9	21.5	258.00	20.55	269.8	6.93	260.9	7.29

Environmental parameters during the experiment



Treatment effects on NH_3 gas emission fluxes from liquid cattle manure during short-term storage, mg/m$_2$/h

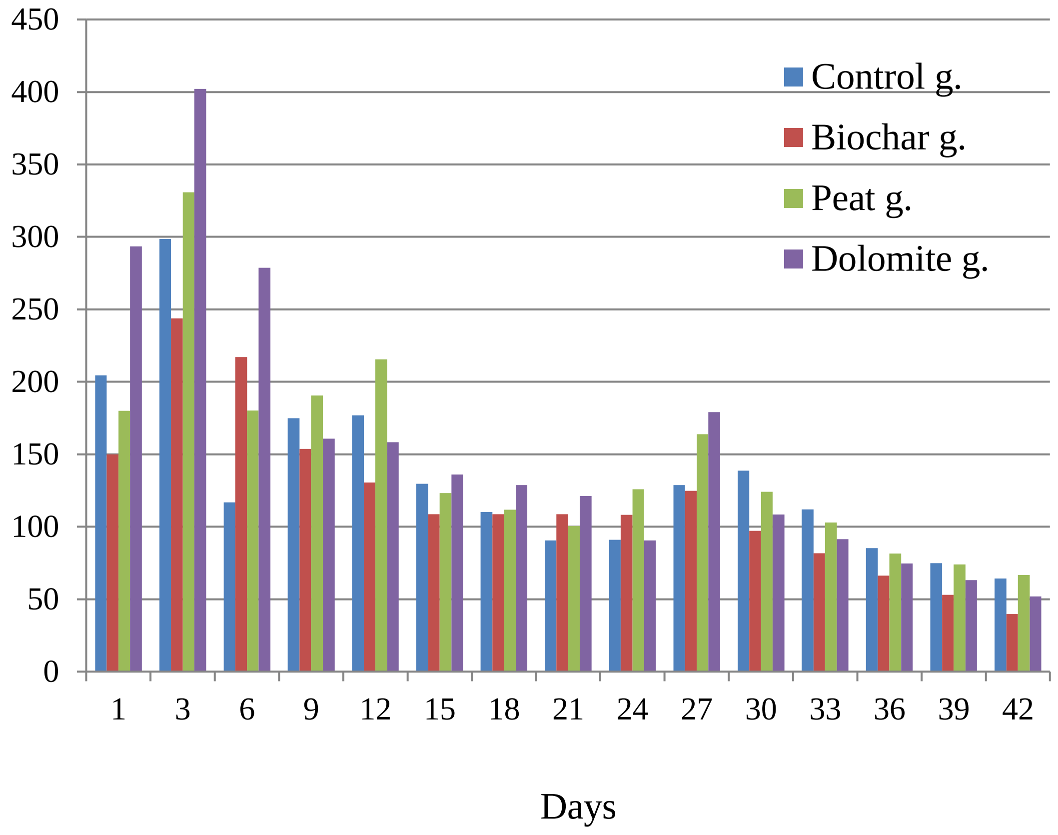


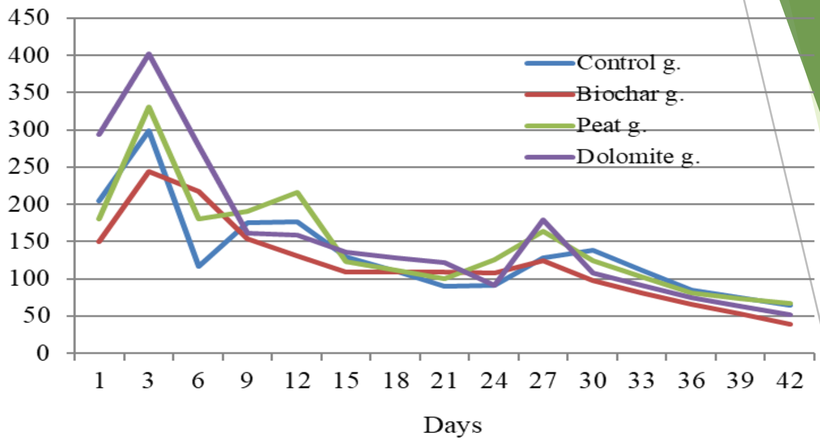


NH_3 production from cattle manure during the study period

Group	Cumulative NH_3 production, kg/m^2	Average per day, g/m^2
Control	0.39	9,36
Biochar	0.37	8,78
Peat	0.40	9,43
Dolomite	0.39	9,27

Treatment effects on CO_2 gas emission rate fluxes from liquid cattle manure during short-term storage, mg/m$_2$/h

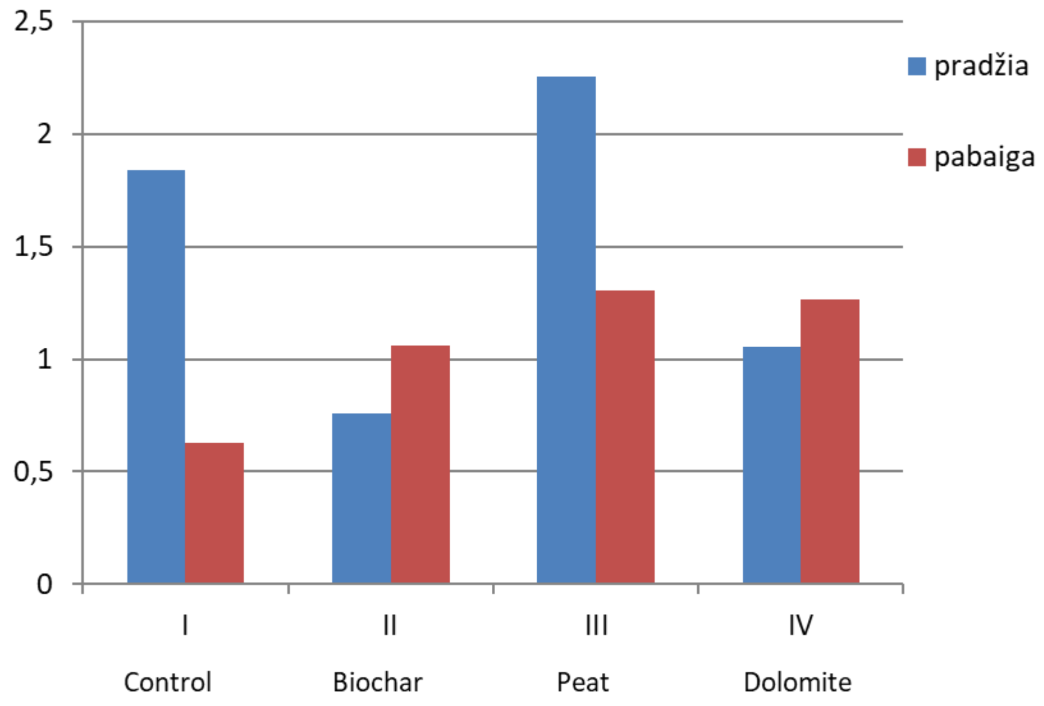




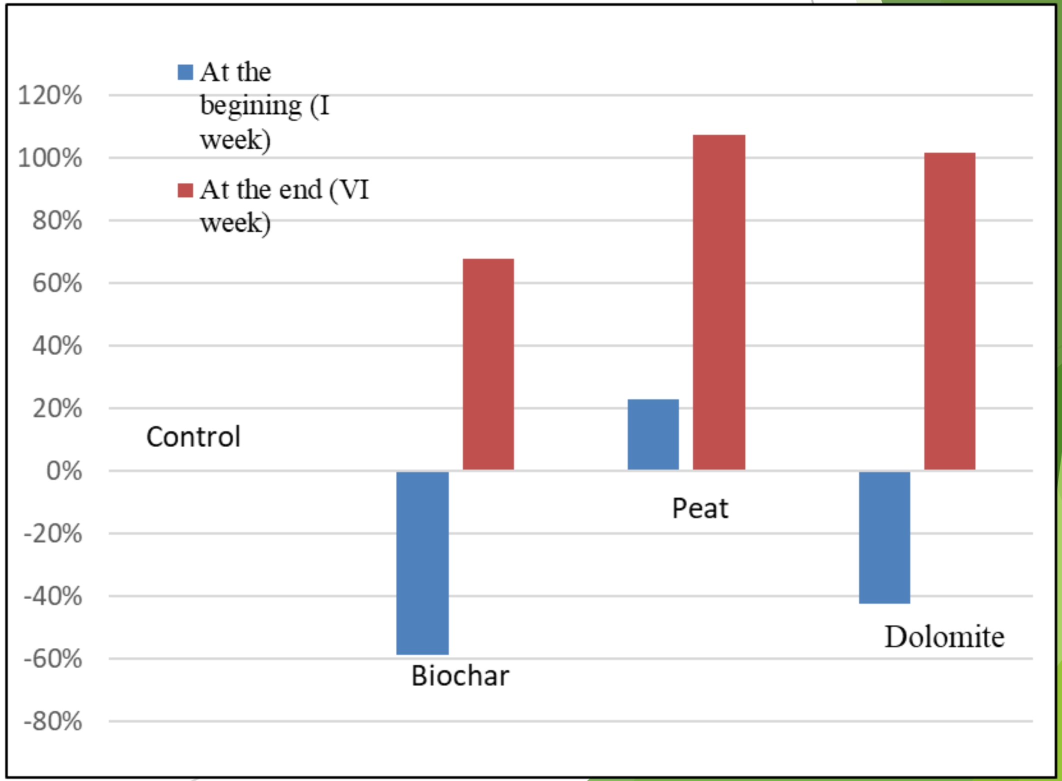
CO_2 production from cattle manure during the study period

Group	Cumulative CO_2 production, kg/m^2	Average per day, g/m^2
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_4 concentration (mg/m$_3$) during short-term storage of liquid cattle manure



CH_4 emission from manure compared to the control group without sorbents



Correlations between CO_2 and NH_3 emissions and treatments

Groups/gases		CO_2				NH_3			
		I	II	III	IV	I	II	III	IV
CO_2	I								
	II	0,939							
	III	0,983	0,960						
	IV	0,948	0,963	0,939					
NH_3	I	0,874	0,837	0,838	0,947				
	II	0,891	0,874	0,869	0,967	0,990			
	III	0,873	0,815	0,831	0,937	0,987	0,989		
	IV	0,871	0,859	0,845	0,961	0,989	0,997	0,991	

CONCLUSIONS

The results of this laboratory study indicated that the highest emission values of ammonia and carbon dioxide **d**uring 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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