BIOTREATMENT IMPACT ON DYNAMICS OF MANURE COMPOSITION AND THE REDUCTION OF AMMONIA EMISSION FROM AGRICULTURE

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INTRODUCTION

The global ambition is to limit global warming potential to 2 °C, so all European Union countries committed to reduce global greenhouse gas emissions to 30% comparing to 1990 level [1]. The most significant harmful gases include carbon dioxide, methane, and ammonia, which has negative effects on environment, health of animals and people. Cattle manure harbors microbial constituents that make it a potential source of pollution in the environment and infections in humans [2].

By controlling ammonia emissions from agriculture therefore the need for analogous estimates of air pollution is increasing significantly [3]. In order to simultaneously reduce the risk of gas emissions from farm animals, the release of gases into the atmosphere must be controlled and reduced [4, 5].

Air pollution, eutrophication and soil acidification cause reactive nitrogen emissions to the atmosphere [6, 7]. Ammonia emission setting up with all manure management models - keeping of animals, grazing, storage, and divert injection reduce ammonia emission into the soil [8, 9]. The principal key categories for NH_3 emissions are animal manure applied to soils, inorganic N-fertilizers, and manure management. They jointly make up 52% of total NH_3 emissions. A single sector group, agriculture, is responsible for most (92%) of the NH_3 emissions in the EU [10]. In Europe, approximately 80% of NH_3 emissions responsible for the acidification of soil originate from livestock production [11, 12].

The modernization of the livestock buildings often involves issues related to ambient air pollution, such as the application of littered or un-littered livestock keeping technology. Scientific results showed that NH_3 emissions increased linearly with increasing air temperature (ºC) inside the barn by 1.47 g [NH_3] cow^{-1} d^{-1} when temperature increased by one degree. [13]. It was determined the impact of climate parameters (temperature, relative humidity) on concentrations of harmful gases (carbon dioxide-CO_2, methane-CH_4 and ammonia-NH_3) such a negative impact on the atmosphere [14]. Reduction of the dairy building temperature could reduce pH and biological activities which create ammonia in the manure [15]. The effect of air emission and ventilation rate on NH_3 effect in animal husbandry, ammonia emission is 37% higher with lower ventilation rate (5-16 m^3 h^{-1}) than with intensive ventilation (15–40 m^3 h^{-1}) [16, 17]. To reduce the atmospheric pollution, it is recommended to conduct detailed research to find the optimal ventilation rate and ambient temperature in cattle barns.

Considering the reason for the formation of ammonia emissions – the bacterial and enzymatic degradation of organic components in the excrement, it is important to determine the influence of 100% natural biotreatment composition on the emission of ammonia from organic waste and to find the optimal method practice. The microorganisms contained in the biotreatments can assimilate nitrogen from urea and exhibit antagonistic activity against the pathogens that produce metabolites that cause bad smells; as a result, the substrate is deodorized [18]. The bio-preparation slightly affects the enhanced removal of total nitrogen (7.40%) and ammonia nitrogen (15.30%) [19, 20]. Other scientists think that the use of biological methods can improve the quality of the environment in livestock farming, reduce the economic costs of manure storage and disposal, improve soil, yield, producing organic food and feed. Solutions are sought for using biotreatments that aid in reducing the intensity of ammonia emission from manure [21].

There is also a great need to find and develop microbiological biotreatments containing microbes that naturally occur in manure [22] that will be able to remove odorous compounds and disinfect the livestock buildings. It is relevant to carry out detailed researches on livestock manure in order to determine the effect of biological agents on the emission of ammonia depending on the manure storage time and the variation in airflow over the layer of manure and other factors

The study of the process of ammonia evaporation from manure evaluated the benefits of the mixture of biological preparations in reducing odors, increasing the rate of organic decomposition, general hygiene of premises and the environment.

The aim of the research is to evaluate biotreatment (Azospirillum sp. (N), Frateuria aurentia (K), Bacillus megaterium (P), seaweed extract, phytohormones, auxins, cytokinin, gibberellins, amino acids, vitamins) effect on dynamics of cattle manure composition and reduction of ammonia emissions.

MATERIALS AND METHODS

Supramental researches were used to identify the effect of biotreatment on reduction of ammonia emission from manure, considering the dynamics of manure composition. It was evaluating cattle manure, because most ammonia is released into the environment by keeping cattle (approximately 50%) and from liquid manure why it was used for researches. Cattle manure samples randomized were taken from barn and homogenized.

Researches have been carried out to determine the manure composition and ammonia emissions from stored manure without biotreatment and using manure biotreatment. Biotreatment is manure treating with 100% natural composition measure solution, which contain of *Azospirillum* sp. (N) number of bacterial colonies – 1x109 cm^{-3}, *Frateuria aurentia* (K) number of bacterial colonies – 1x109 cm^{-3}, *Bacillus megaterium* (P) bacterial colony count – 1x109 cm^{-3}, seaweed extract (10% by volume), phytohormones, auxins, cytokinin, gibberellins, amino acids and vitamins mixed with water. The biotreatment is intended for biodegradable manure to turn it into a full-blown fertilizer by combining valuable nutrients. Another combination of adapted bacterial blend is intended to stimulate soil microbiological activity and accumulate high levels of macro and microelements in the soil.

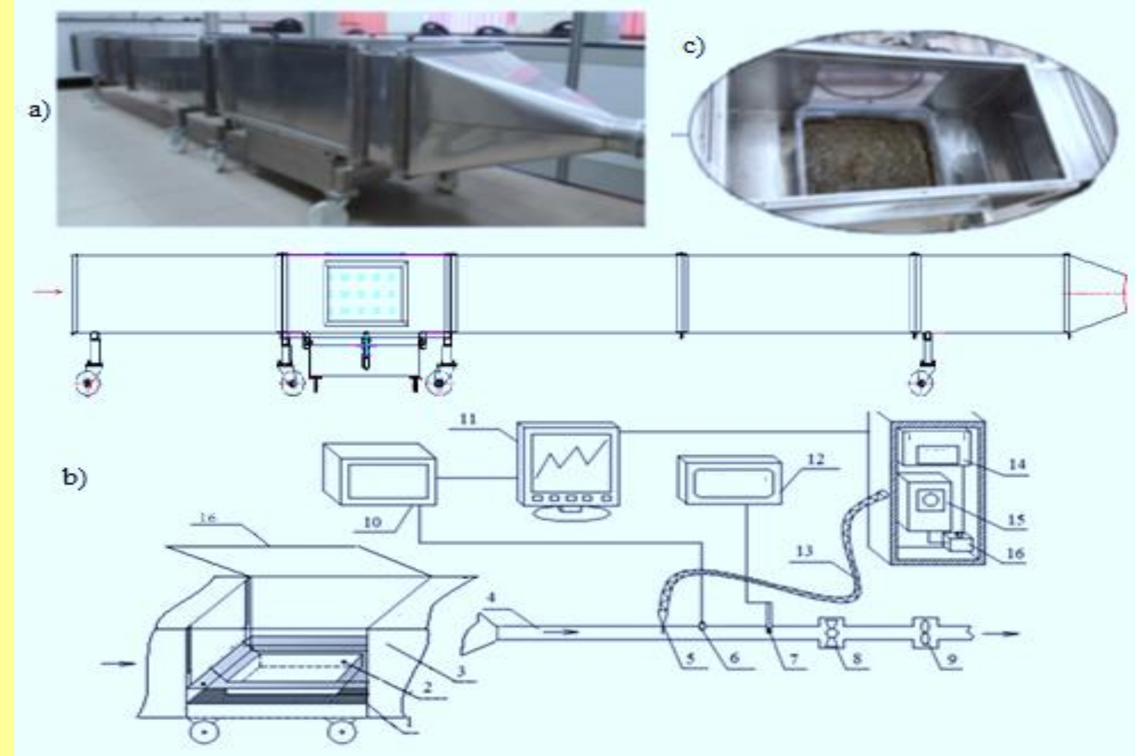


Figure 1. The equipment of the research: a) Wind tunnel;
b) Measurements of ammonia emission and microclimate performances;
4 – an air extraction duct;
5 – air sampling probe;
6 – thermoanemometer sensor;
7 – temperature and humidity sensors;
8 – valve;
9 – fan with frequency converter;
10 – gauge-accumulator "Almemo 2590-9"; 11 – computer (AMR program);
12 – heated air supply hose;
13 – laser gas analyzer "GME700";
14 – electrically heated triple channel valves;
15 – membrane air pump;
c) Test section;
1 – a pallet with wheels mounted on a manure capacity;
2 – a capacity for dung;
3 – a sealed, one-section of a wind tunnel made of transparent material;
16 – the lid.

The agrochemical analysis of the manure composition was carried out before starting an ammonia gas emission research by taking a sample of manure from a homogenized fresh liquid manure. When the results of agrochemical researches were recorded, the mass of manure was divided into two equal capacities: the solution of the biotreatments was added to the manure in the first capacity, and control manure without it was added to the second capacity. The research objects were kept for 49-96 days in every of 5 repetition (until the end of the biotreatment was effective), and in every period of 7, 14, 21, 28, 35, 42, 49 days, the ammonia emission intensity was summarized, because ammonia concentration average values were fixed in every research minute and then calculate to emission values. At the end of every researches repetition (after 49 to 96 days (depend on the end of the effectiveness of biotreatment)), analogous manure agrochemical researches were repeated.

It was carried out researches on manure composition content and established ammoniacal nitrogen content, nitrogen nitrate (N-NO_3) content using LVP D-05: 2017.91 Edition - Flow analysis (FIA) spectrometric method, total nitrogen content, total phosphorus (P_2O_5) content, total potassium (K_2O) content – using LVP D-07: 2016,91 Edition - Egner-Rime-Domingo (A-L) method. The manure content of dry matter is determined according to the requirements of standard LST 1530: 2004. The sample, prepared for drying, is placed in a Memmert Model 100-800 drying oven, and dried at 105 °C to a constant weight (by 8 repetitions). The value of pH in manure is determined by a pH meter HI98129-HI98130 (range from 0 to 14.0 pH, accuracy ± 0.05 pH).

The assessment of manure biotreatment effect on gas emission was carry out using homogenized manure samples placed in a wind tunnel. The manure sample was biotreated by spraying bio solution over a 0.16-0.20 m layer which a surface area (S) - 0.1748 m^2 (0.38 x 0.46 m). One manure (25 l liquid cattle manure) sample in the capacity biotreated with bio solution, which consist of 5 cm^{-3} mixture composition for manure treatment, 2,5 cm^{-3} mixture composition to stimulate the microbiological activity of the soil and accumulate macro and microelements (all biotreatment consist of *Azospirillum* sp. (N) number of bacterial colonies – 1x109 cm^{-3}, *Frateuria aurentia* (K) number of bacterial colonies – 1x109 cm^{-3}, *Bacillus megaterium* (P) bacterial colony count – 1x109 cm^{-3}, seaweed extract (10% by volume), phytohormones, auxins, cytokinin, gibberellins, amino acids, and vitamins), 100 cm^{-3} of water (H_2O). The control untreated manure sample prepared in the other capacity with 25 l liquid cattle manure and sprayed with 100 cm^{-3} of H_2O.

Emission of ammonia from manure have been carried out on a specially reconstructed experimental research unit (Fig. 1).

The GME700 analyzer was used to measure the concentration of ammonia (NH_3) gas (Fig. 1). NH_3 gas measurements range from 0 ppm to 2000 ppm. This principle of measuring the device is laser spectroscopy. The air samples taken from the duct with probes and the heated hose are supplied to the GME700 gas analyzer. The analyzer hoses that draw air into the analyzer are specialized and heated to 150 degrees Celsius to prevent condensation. The analyzer preheats the pumped gas, and therefore, the gas conditioning ensures that the cell is not contaminated and does not form condensation. Electro-heated triple-bar valves are used to ensure that the operating temperature exceeds the temperature of the sample dew point. Operating mode: automatic (continuous or cyclic measurement with data accumulation). The air temperature and humidity are measured with temperature and humidity sensors connected to the Almemo 2590-9 system (temperature range from 30 to 60 °C, relative humidity of the air from 5 to 98%, accuracy of the device ± 0,1%).

The air in the analyzer is supplied by an uninterrupted pump (15) with a capacity of 6 l min^{-1}. For the exclusion of air condensation, it is warmed up in the intestine (12) and heated to 150 °C in the electrically heated valve (14). The test gas analyzer (13) is programmed to record the concentration of ammonia gas every 1 min. At the start of the test, the analyzer readings stabilize on average every 1-2 minutes, and then the ammonia gas concentration is captured. The emission intensity is calculated according to equation (1).

Gas emission was researched using the mass flow rate method and laser spectroscopy sensors by measuring gas concentrations (Fig. 1). Identifying intensity of the capacity ventilation G (m^3 h^{-1}) and the concentration of gas Ce (mg m^{-3}) entering in the capacity and outgoing from its Co, the gas emission intensity is calculated.

RESULTS

Significant changes in manure composition were observed for biotreated and final 96-day manure compared to fresh manure.

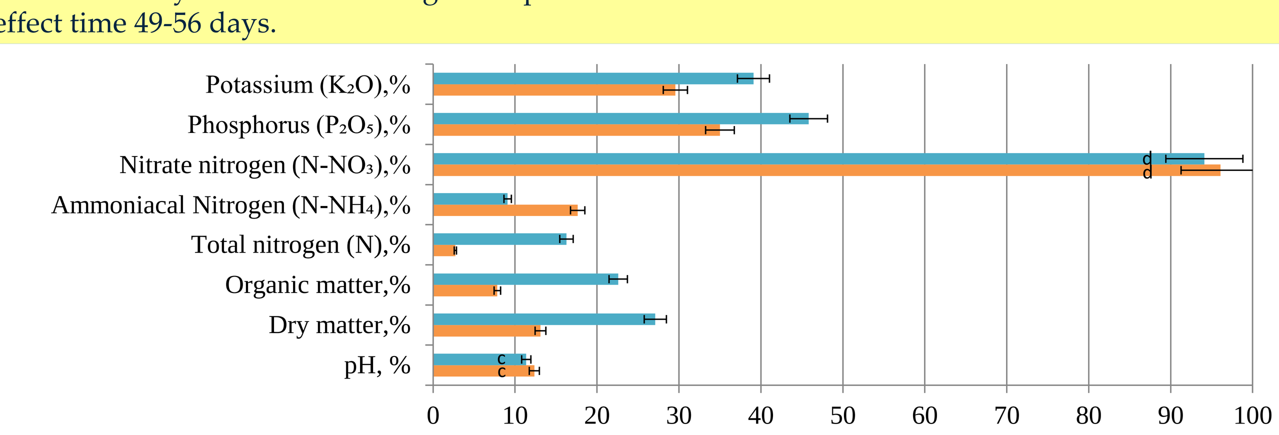
Only a percentage decrease of nitrate nitrogen was found.

Percentage difference manure composition parameters - pH, dry matter, organic matter, total nitrogen, phosphorus, potassium using manure biotreatment was approximately 15% (Fig. 2).

The difference in ammonia nitrogen variation comparing control and biotreated manure is 24%. The minimum difference in pH between control and biotreated manure is possible and can be considered for the pH difference of final 96 days at the end of the research. The highest manure biotreatment effectiveness identified till 35% in nitrate nitrogen (N-NO_3).

In sum, most of the established manure composition parameters have not changed significantly. The most significant differences were found in the parameters of organic matter and dry matter in both variants from 0.67 to 3.95 in the overall research. The differences between the control and the biodegradable manure composition parameters, the highest percentage difference of nitrate-nitrogen was established, and the pH difference between manure was not detected at the end.

It was established 32% manure biotreatment effect on reduction of ammonia emissions. The maximum effect of the biodegradable compound on gaseous propagation was assessed after 28-35 days of manure storage and proved all biotreatment effect time 49-56 days.



	pH, %	Dry matter,%	Organic matter,%	Total nitrogen (N),%	Ammoniacal Nitrogen (N-NH₄),%	Nitrate nitrogen (N-NO₃),%	Phosphorus (P₂O₅),%	Potassium (K₂O),%
Biotreated manure composition change, %	11.36	27.11	22.59	16.28	9.09	94.12	45.83	39.10
Control manure composition change, %	12.36	13.09	7.84	2.70	17.65	96.08	35.00	29.57

Figure 2. Control and biotreated manure composition percentage change; manure biotreatment effect on manure composition. The letters indicate substantial differences between the factors. Uniform letter shows that there is no substantial difference.

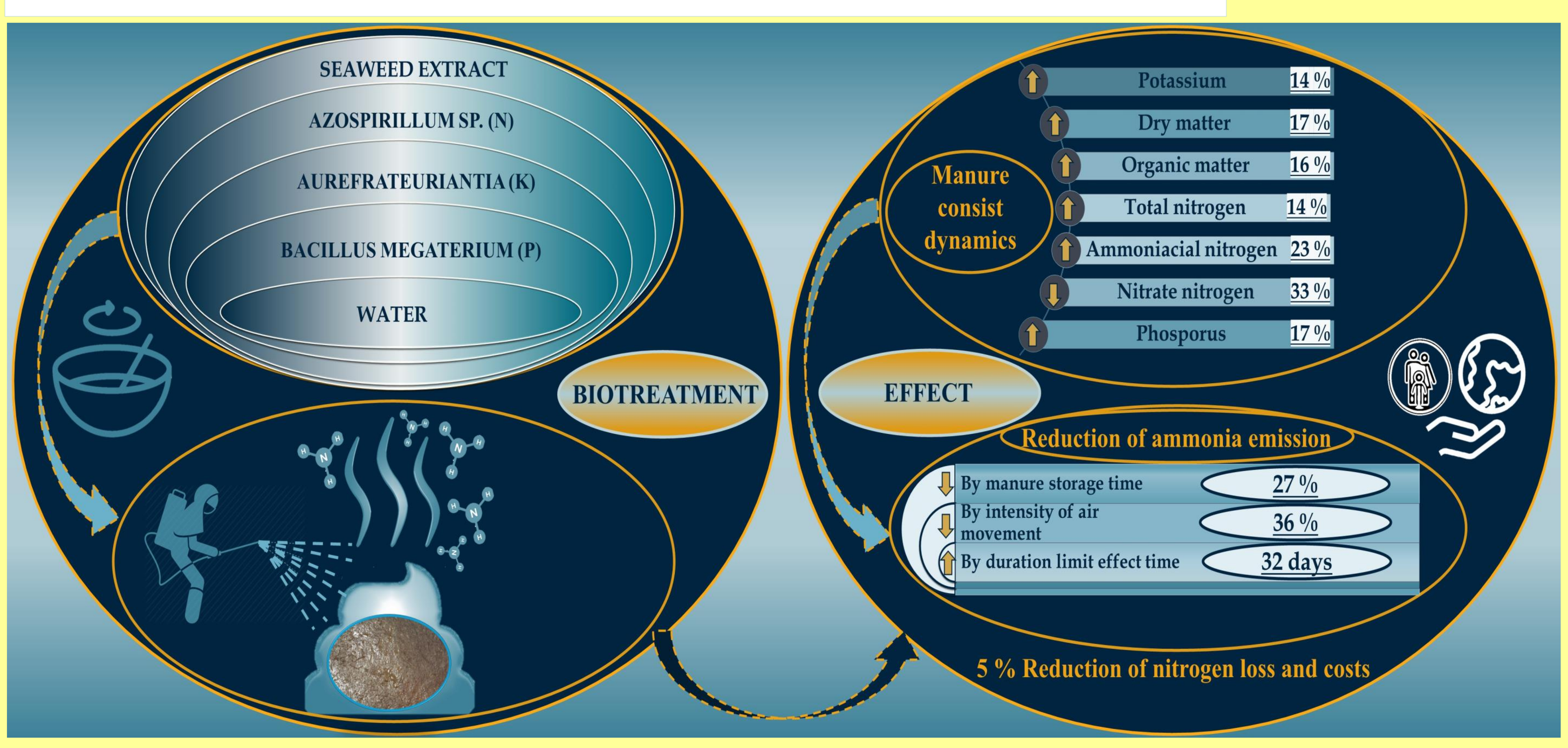


Figure 3. Biotreatment impact on dynamics of manure composition and the reduction of ammonia emission.

Table 2. Manure biotreatment effect on ammonia emission reduction (%) dependence on dynamics of manure pH (%), dry matter (%), organic matter (%), total nitrogen (%), ammoniacal nitrogen (%), nitrate nitrogen (%), phosphorus (%), potassium (%).

	Percentage difference of biotreated manure	Result
pH,%	1,12	Increase
Dry matter,%	16,13	Increase
Organic matter,%	16,01	Increase
Total nitrogen (N),%	13,95	Increase
Ammoniacal Nitrogen (N-NH₄),%	22,73	Increase
Nitrate nitrogen (N-NO₃),%	33,33	Reduction
Phosphorus (P₂O₅),%	16,67	Increase
Potassium (K₂O),%	13,53	Increase
Amonnia evaporation after 7 days	15,49	Reduction
Amonnia evaporation after 14 days	32,78	Reduction
Amonnia evaporation after 21 days	57,02	Reduction
Amonnia evaporation after 28 days	16,00	Reduction
Amonnia evaporation after 35 days	7,95	Reduction
Amonnia evaporation after 42 days	57,04	Reduction
Amonnia evaporation after 49 days	2,92	Reduction
Amonnia evaporation after 70 days	36,26	Reduction

The analysis of the residual linear regression model used in the ammonia emission experiment showed that the model is acceptable because the model's uncertainty is determined by the coefficient of determination, and the obtained results reflect almost equal coefficient variation. Manure biotreatment effect on ammonia emission reduction depend on manure pH, dry matter, organic matter, total nitrogen, phosphorus, potassium increases and nitrate nitrogen reduction. No significant manure biotreatment effect on ammonia emission reduction dependence has been identified on the ammoniacal nitrogen. In general case trend manure biotreatment usage was more effective on ammonia emission reduction dependence on bigger linear increase of pH, dry matter, organic matter, total nitrogen, ammoniacal nitrogen, potassium comparing with control. Then, having the values of the percentage change rather than the initial results, we can partially absolute, because such a percentage change would be independent of the exact specific initial values.

In abstraction all different biodegradation impact assessments could be confirmed that manure biotreatment reduce ammonia emissions through dynamics of manure compositions and increased emission of ammonia from manure affects the biggest impact of biological measurements on suppressing gas emission. Less ammonia emission will make the organic fertilizer created more valuable.

For the European Union, to implement the green course, the main goal is to abandon the use of mineral routes. Therefore, the substantial benefits are assessed through the reduction of air pollution. By reducing ammonia emissions, we conserve nitrogen.

CONCLUSIONS

1. It is recommended that manure biotreating by spraying with solution which consist of *Azospirillum* sp. (N) number of bacterial colonies – 1x109 cm^{-3}, *Frateuria aurentia* (K) number of bacterial colonies – 1x109 cm^{-3}, *Bacillus megaterium* (P) bacterial colony count – 1x109 cm^{-3}, seaweed extract (10% by volume), phytohormones, auxins, cytokinin, gibberellins, amino acids and vitamins could be used to reduce ammonia emissions in cowsheds where liquid manure is accumulated. Its use is in line with the tendencies of the environmental policy of cowsheds to install crayfish, liquid manure technologies, where manure is held in the canals for a short time, during the warm period.

2. Identified the manure biotreatment effect on the ammonia emission rate from manure - ammonia emissions can drop to 32%. The greatest effect is observed after 28-35 days; then it decreases and disappears after 49-56 days. Assessed when greater the emission of ammonia from manure, then became more greater the effect of the manure biotreatment on suppressing gas emission too.

3. Manure biotreatment usage was more effective on ammonia emission reduction from manure dependence on increase of dry matter, organic matter, total nitrogen, ammoniacal nitrogen, potassium, phosphorus respectively up to 16.13%, 16.01%, 13.95%, 22.73%, 13.53%, 16.67%.

4. By the saving nitrogen loses priority, manure biotreatment will reduce ammonia emissions, nitrogen losses from manure and inorganic N fertilizers by approximately 5%, also could reduce approximately 5911.1 thousand tonnes nitrogen fertilizer in the world and reduce approximately 5.5 Eur / ha.

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