

THE NUTRIENT POTENTIAL OF ORGANIC MANURE AND ITS RISK TO THE ENVIRONMENT

Daniela Giosanu ^{1,*}, Felicia Bucura ², Marius Constantinescu ²,
Anca Zaharioiu ², Loredana Vîjan ¹, Gabriela Mățăoanu ¹

¹ University of Pitesti, Târgul din Vale Street, No1, Pitești, Romania

² National Research and Development Institute for Cryogenics and Isotopic Technologies – ICSI Rm. Vâlcea, Romania



Abstract

The livestock sector is an important component of agriculture that involves the breeding of various types of domestic animals. Although animal husbandry is a key activity in global food production, providing food for human society, income, jobs, nutrients, etc. it also has negative consequences, being the second largest polluter after the power industry. An important issue related to the livestock sector is manure produced by animals. The purpose of this paper is to understand the potential of organic manure nutrients as well as the negative effects they can have on the environment. In order to carry out the study, investigations were required regarding the calorific value and the elementary analysis (C, N, H, S, O) for five different types samples of manure from: poultry, sheep, cow, horse and pig. All types of manure have a moisture content of between 40-60% and can be used for composting. With manure we can produce biogas, but is necessary to know the correct way of managing manure in order not to lead to pollution

Keywords: calorific value, elementary analysis, livestock sector, manure, organic nutrients.

1. INTRODUCTION

The livestock sector is very important because it has both advantages and disadvantages. The most common advantages are that livestock farming provides the population with the necessary food, jobs, raw materials, organic fertilizers. The livestock industry has a negative impact on the environment, being responsible for climate change (Grossi et al., 2018). The main greenhouse gasses produced by livestock farming are: carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), and ammonia (NH₃). Due to animal husbandry, the limit for carbon dioxide could be exceeded in the future, as animals naturally release CO₂ (Halmaciu et al., 2022). Another problem in livestock production is the generation of manure. Since the 21st century, more than 30 million tons of manure are produced annually worldwide, and the trend is increasing (Li et al., 2020). The rearing of animals results in large amounts of residual organic matter of liquid, solid and, semi-liquid consistency. An advantage of these residual organic matter is that they can be used to fertilize agricultural land (Köninger et al., 2021). When the number of animals is much higher than the optimum for the agricultural land of the area where the livestock activity takes place, the amount of manure exceeds the possible need to be used as organic fertilizer, so that it becomes waste to be stored and then disposed of (Tullo et al., 2019).

Although manure is an important source for maintaining soil fertility, its management has become one of the major environmental problems, causing great harm to human health and the environment if not properly managed (Li et al., 2020).

The most important nutrients found in manure are: nitrogen, phosphorus, potassium and trace elements. The amount of nutrients varies from animal to animal (Khoshnevisan et al., 2021).

The field application of manure provides nutrients and microelements useful for growing crops, but also elements that can accumulate in their tissues and enter the food chain (Tullo et al., 2019).

Manure is a valuable resource if handled responsibly, but a source of serious challenges and public health problems if mismanaged. Therefore, it is advisable to know its content and how to use it in way that does not pollution.

2. MATERIALS AND METHODS

In order to carry out the study on the potential of the nutrient resources of organic manure, investigations were needed on caloric power and the elementary analysis (C, N, H, S, O) of manure samples from different animals.

For this experiment, samples of manure from five different types of animals were used: poultry, sheep, cow, horse and pig.

The first phase of the working process consisted in the homogenization of the samples; then, the thermobalance in the image below was used to determine the moisture.



Figure 1. Thermobalance

After that, the samples were placed in the drying stove. Finally, a solid, dry matrix with a specific odor resulted.

The ash content was also determined, being a very important aspect because it is a first information about the amount of waste resulting from a combustion of this type of matrix that could constitute an alternative fuel/raw material.

By determining the content of volatile matter, we obtained information about a content specific to solid fuels, and in the case of manure we observed a higher level of these than in the case of conventional fuel (fossil, anthracite, coke and lignite).

After these gravimetric tests, the investigations of the elementary content followed.

The EA2000 elemental analyzer was used to determine the elements with the greatest impact on the environment. The samples subjected to the combustion process, manure/solids, are determined in the form of oxides: CO₂; H₂O; SO₂; NO₂ and then converted into the elements N; C; H; S. The analyzer collected information about the content of the raw material, about the level of some elements with energy character / potential – H, C (Constantinescu et al., 2019).

The qualitative and quantitative level of oxygen in various solid and liquid samples were investigated using the pyrolysis + gas method. The pyrolysis method combines intramolecular oxygen with organic carbon, resulting in carbon monoxide, which is converted by this method, in the form of a peak, which represents the oxygen content of the investigated sample.

Finally, the calorimeter (C5000, IKA, Germany) in the figure below was used to indicate the energy values, the upper calorific value HHV and the lower calorific value LHV for the raw material, by the combustion method, the calorimetry and the adiabatic method, respectively (Zaharioiu et al., 2020).



Figure 2. Calorimeter C5000, IKA

The amount of sample used to determine the energy value varied, ~ 0.50 g ↔ 1.00 g. The sample was subjected to combustion in a combustion vessel called an *oxygen bomb*.

The results are presented in the form of tables and graphs.

3. RESULTS AND DISCUSSIONS

By analyzing all the manure samples from the five different types of animals, we obtained the following results.

The moisture content of each manure sample can be observed in the table below. For each sample, three determinations were made to indicate the exact moisture content.

It can be seen that horse manure has the lowest moisture content, its values being: 47.51%; 46.23%, and 47.43%. The highest amount of moisture is found in poultry manure, with the following values: 58.17%; 58.81%; 59.28%.

All types of manure have moisture content between 40-60%.

Table 1. Moisture content

Manure / type	Moisture (%)		
	Poultry	58.17%	58.81%
Sheep	53.21%	54.15%	53.09%
Cow	53.44%	52.61%	52.96%
Horse	47.51%	46.81%	47.43%
Pig	54.38%	54.23%	54.11%

For composting, the organic material that decomposes must be moist, but not too wet. At lower moisture levels, microbial activity is limited, and at higher moisture levels, the process can become anaerobic and smell foul. Composting occurs best at a moisture content of 40-60%.

Thus, all of the manure types studied fall within this range and can be used for composting.

The following table shows our determinations regarding: the concentration of the component elements (H, N, S, C, O), the ash content (A), the volatile matter content (V), higher and lower calorific value (Q_s and Q_i).

Table 2. Investigation results

Manure / type	H ^a (%)	N ^a (%)	S ^a (%)	C ^a (%)	A ^a (%)	Q _s ^a (kcal/kg)	Q _i ^a (kcal/kg)	V ^a (%)	O ^a (%)
Poultry	5.02	4.32	0.37	37.18	22.44	3183	2920	62.55	30.675
Sheep	5.43	1.90	0.24	42.43	16.78	4116	3832	65.82	33.220
Cow	4.82	2.63	0.36	38.91	34.45	3475	3222	52.36	18.834
Horse	5.87	1.16	0.23	45.78	9.11	4764	4456	69.80	37.852
Pig	6.12	2.67	0.21	44.38	13.16	4140	3819	69.16	33.457

Note: a - analysis status (samples without moisture)

The quality of manure as fertilizer and fuel depends primarily on moisture content, but also on ash. In the table above, A^a represents the ash content of the samples tested. The manure with the highest ash content is cow manure with a value of 34.45%, and the manure with the lowest ash content is horse manure with a value of 9.11%.

The volatile matter content V in each manure sample was further determined. All types of manure had a very high level of volatile matter. Their level was higher than fossil fuels: anthracite (2-12%), lignite (45-55%). The maximum value was 69.16%, belonging to horse manure, and the minimum value was 52.36%, belonging to cow manure.

The elemental content of each manure sample was determined by analyzing the following elements: N; C; H; S; and O. The laboratory analyzes showed that sulfur was the lowest element and carbon was the highest element. The order of the elements with a major environmental impact which have been determined by the combustion method + the gas method is as follows: S < N < H < C. This can also be seen from the chromatogram below.

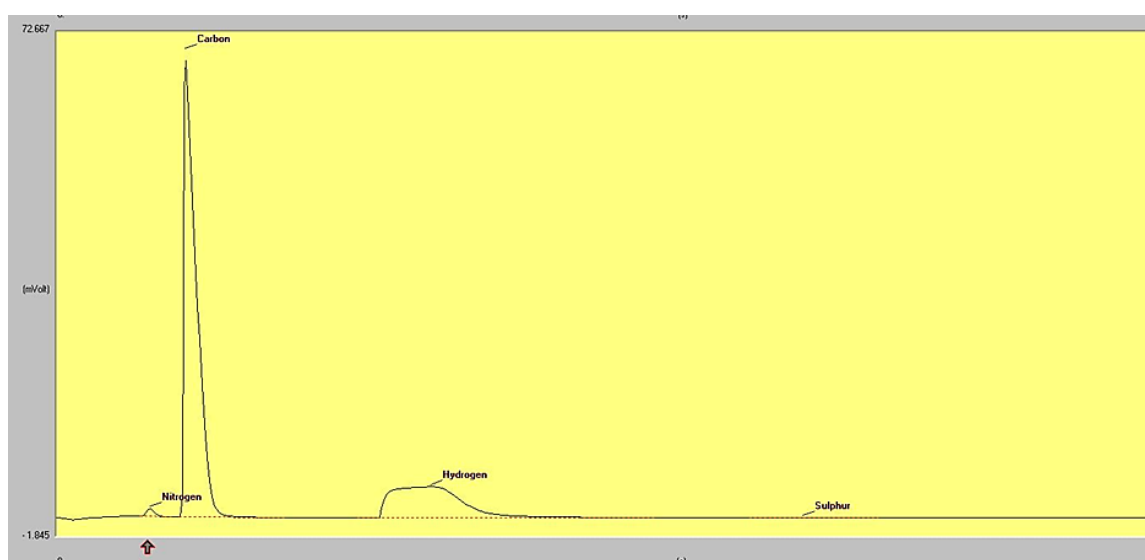


Figure 3. Chromatogram of the elementary investigation of manure

Among the primary nutrients in manure are N and S that were analyzed in this experiment.

The results of the analyzes showed the following: all types of manure had a high nitrogen content and a low sulfur content. The manure with the highest nitrogen content is poultry manure with a value of 4.32% and the manure with the lowest nitrogen content is horse manure with a value of 1.16%.

The amount of nitrogen varies depending on several factors. The amount of nitrogen may vary, for example, depending on the weight and type of animal. The manure of animals rich in nitrogen may be due to the feeding of animals with concentrated fodder and hay. If manure was low in nitrogen, then this was due to feeding the animal's fibrous feed. All types of manure showed small amounts of sulfur, the maximum value being 0.37% (poultry manure) and the minimum value, 0.21% (pig manure).

Due to the nutrients present in manure, such as N, manure can have the following beneficial uses: it can be used as compost, fertilizer, soil amendment, etc.

Following the results obtained, the most nutrient-concentrated manure is poultry manure. Thus, poultry manure, being the richest in nitrogen, may be the best option to choose.

Certain elements of manure, such as carbon, can be used to produce fuels for heating, transport and to generate electricity. Thus, in the table above it can be seen that the level of some elements with energetic character / potential, that is, C and H, was also determined.

The highest values are those of carbon. Manure with a high carbon content is horse manure with a value of 45.78%, and manure with the lowest carbon content is poultry manure with a value of 37.18%.

The amount of H present in the manure is much less than the amount of carbon. The lowest amount of hydrogen is in cow manure (4.82%), and the highest amount of hydrogen is in pig manure (6.12%).

In the table, it can be seen that the oxygen level for each manure sample has also been determined because it is an important parameter. The lowest value was found for cow manure (18.834%) and the highest value for horse manure (37.852%).

The table also shows the values of higher calorific value Q_s and lower calorific value Q_i obtained after using the calorimeter. Calorific value is an important indicator for measuring energy content. Q_s showed much higher values than Q_i ($Q_s > Q_i$).

Maximum values were recorded for horse manure with $Q_s = 4764$ kcal/kg and $Q_i = 4456$ kcal/kg and minimum values for poultry manure with $Q_s = 3183$ kcal/kg and $Q_i = 2920$ kcal/kg.

Since nitrogen is one of the main nutrients found in manure, below you can see a graph consisting of the variation in calorific value depending on the concentration of N.

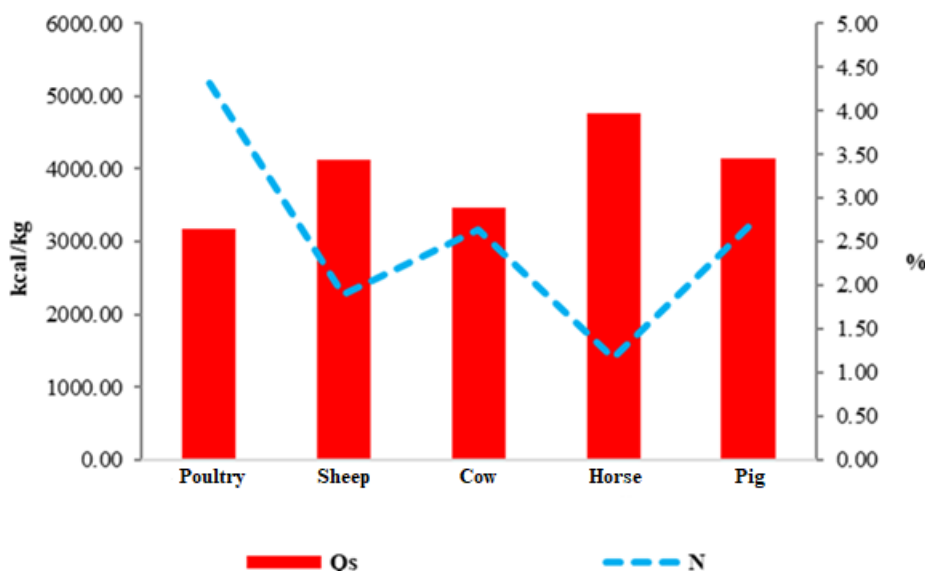


Figure 4. Variation of calorific value depending on the concentration of N

The graph above uses the values of the higher calorific value Q_s and the values of N in Table 2.

The following can be seen on the graph: horse manure with the highest calorific value $Q_s = 4764$ kcal/kg has the lowest quantity of N (1.16 %), and poultry manure with the lowest calorific value with $Q_s = 3183$ kcal/kg contains the highest amount of N (4.32%). The higher the amount of nitrogen, the lower the calorific value.

4. CONCLUSIONS

Livestock breeding practiced all over the world, is of great importance because it is not only a source of food necessary for human but also produces a large amount of manure.

Livestock manure is an excellent source of nutrients such as nitrogen, phosphorus, potassium and sulfur. The nutrient-rich content of manure brings many benefits, such as: the use of manure as organic fertilizer, compost. Due to the nutrients it contains, manure contributes to growth of plants and fertilizes the soil. Therefore, is important to determine the nutrient content of manure, to find out what kind of manure contains more nutrients, so that it can be used. In the present work, after analyzing five different manure samples, it turned out that the largest amount of nitrogen is found in poultry manure, so it is a good option to be used as fertilizer. In the case of combustion, manure with a high nitrogen and sulfur content leads to the formation of oxides that lead to pollution. Therefore, it is not advisable to burn it alone, but in combination with vegetable waste or weaker coals, such as lignite. In our case, poultry manure has the highest nitrogen and sulfur content.

It is also good to know the amount of elements of character/energy potential (C and H) that are in the manure. Another important benefit is that manure can be used as an alternative source of natural fuel for energy generation. This would help reduce human dependence on fossil fuels, which are non-renewable sources of energy that lead to pollution. In order to be used as fuel, manure will have to contain a sufficient thermal value to make the process cost-effective. Thus, in this work was also determined the calorific value of manure.

In this paper, it was shown that the sample with the highest carbon content has the highest energy potential. Thus, from an energy standpoint, horse manure is the best because it has the highest carbon content. Poultry manure has the lowest energy value because it has the lowest carbon content.

With manure we can produce biogas, which is a renewable energy source and can be used to produce: fuel for vehicles as well as for heating and electricity generation.

It is also important to know the right way to handle manure to avoid pollution.

Therefore, we should give special importance to manure, because it is a very valuable source.

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