

Obtaining fertilizers from organic waste

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Abstract. One of the serious and acute problems of our century is the problem of protecting the natural environment from the negative effects of various wastes that are generated by constantly increasing human economic activity. In order to protect and protect water resources, atmospheric air, soils, and for the use of various valuable components contained in the generated waste, new and diverse waste processing technologies are being developed and implemented every day. In this regard, the article presents a new way of processing chicken waste, lowering its pH by diluting it with appropriate acids. This is a chemical processing method. Due to the binding by chemical bonds, nitrogen remains in the fertilizer as a useful trace element.

1 Introduction

The problem of healthy nutrition remains relevant for humanity. This fact everywhere gives rise to a steadily growing demand for so-called "environmentally friendly food". The Agency for Strategic Initiatives (ASI), together with the business community, presented in September 2017 a road map for the development of the FoodNet food market, which is part of the National Technology Initiative (NTI). One of the "breakthrough" segments identified by ASI is the development of organic farming. The use of processing of all types of organic waste and obtaining a highly efficient organically pure fertilizer without the formation of secondary waste is one of the promising areas of organic farming.

In accordance with the "Concept of development of agrochemistry and agrochemical services of agriculture of the Russian Federation", the country's agriculture needs for organic fertilizers is 800 million tons, but their use does not exceed 10-15%.

The use of bird droppings as fertilizers is of great importance in the agriculture of the Kabardino-Balkarian Republic. Currently, there are 36 officially registered poultry farms in the republic. The report of the Ministry of Agriculture for 2019 provides information on the results of the work of the livestock industry, where the number of poultry in all categories of farms is 3.9 million heads. In a year, one bird (chicken) releases up to 60 kg of litter with an average humidity of about 70%.

The development of poultry farming in the Kabardino-Balkarian Republic has determined the high concentration of poultry in certain limited territories. For example, from the report of the Ministry of Agriculture in 2019, the number of birds is 102% more than in 2018. With

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the growth of the number of birds, the amount of waste also increases, and there is a problem of recycling a significant amount of bird droppings, which for a number of reasons is classified as Class 3 hazardous waste. Poultry farms accumulate droppings, bringing the adjacent territories into an unsatisfactory ecological condition. Waste from enterprises poses a threat to human health, soil and water bodies.

At the same time, bird droppings are a valuable organic fertilizer with a high nutrient content and a satisfactory ratio of nitrogen, phosphorus and potassium for most crops. Therefore, the organization of an enterprise on the territory of the republic for the production of fertilizers based on organic waste **is relevant**.

The aim of the work is to develop a chemical method for processing chicken manure into organic fertilizer using inorganic acids.

To achieve the goal, the following tasks were set:

- Reduction of negative environmental impacts arising from the storage of bird droppings and fertilizer production;
- Reducing the processing time of bird droppings;
- The possibility of processing a large volume of droppings;
- Suppression of pathogenic microflora activity;
- Reduction of the cost of the final product.

Scientific novelty of the work: a new chemical method of processing animal waste, mainly chicken manure, for further production of organic fertilizers based on them has been developed, optimal concentrations of inorganic acids have been selected and chemical and microbiological studies of the samples obtained have been carried out.

Practical significance of the work.

The problems that are solved in this work can be divided into two groups.

The first group includes the problems faced by poultry farms:

- method of disposal of chicken manure,
- payment of fines for incorrect, untimely disposal of organic waste.

Starting from 2022, in accordance with the Federal Law "On Production and Consumption Waste" dated 06/24/1998 No. 89-FZ (latest edition), as well as SanPiN 1.2.3685-21, it is necessary to dispose of organic waste. Administrative Code of the Russian Federation Article 6.3 (the amount of the fine is from 100 to 20,000 rubles, depending on the type of business entity, as well as suspension of activity for up to ninety days., Criminal Code Article 236.(the amount of the fine is 500 rubles, or deprivation of the right to hold certain positions or engage in certain activities for a period of one year to three years, in special cases, the amount of the fine is from 1 million rubles to 2 million rubles, or restriction of liberty for a period of two to four years.

The second group includes agricultural producers who need organic fertilizers and cannot use them due to the presence of pathogenic microflora. The Kabardino-Balkarian Republic is an agrarian republic, the sown area of which is 281.5 thousand. Ha, (data from the Ministry of Agriculture for 2021) and the number of agricultural producers there are 1,167 organizations (according to the Federal State Statistics Service for 2021) and the organization of organic fertilizer production in the republic will contribute to the effective use of chicken manure for fertilizing land, increasing soil fertility and crop yields.

Thus, the disposal of poultry waste in agriculture remains a serious problem, the solution of which is to prevent and eliminate environmental pollution and requires technological solutions optimal in terms of ecological and economic indicators.

2 Scientific and technical characteristics of the project

2.1 Analysis of the current state of the literature on the processing of organic waste

In Russia, there is an active development of agricultural production, including poultry farming. At the same time, along with the growth of the poultry population, there is an increase in the yield of bird droppings [1]. So, S.M. Lukin [2], noted that in 2008, the output of manure from the poultry stock available in agricultural organizations of the country amounted to more than 14 million tons of manure, and in 2010, according to N. Nikulin [3], the production of bird droppings amounted to more than 23 million tons. Currently, there are more than 400 poultry farms operating in Russia, and the output of litter exceeds 30 million tons.

The output of bird droppings. The amount of litter released by different birds varies and depends on the age, species, live weight of the bird, feed quality and conditions of maintenance. The output of the litter from one bird head is: chickens have 6-7 kg, ducks - 7-9 kg, geese - 10-12 kg per year.

The chemical composition of the litter. Poultry manure, especially chicken manure, is a valuable organic fertilizer with a high content of basic nutrients (nitrogen, phosphorus, potassium). Nitrogen and phosphorus in poultry manure is much more than in the manure of cattle and pigs.

Obtaining organic fertilizer from manure. Litter is based on litter and feed residues. It is obtained with the outdoor content of poultry. The most reliable method for preserving nitrogen in the litter is a deep litter in poultry houses. Currently, the litter mainly contains breeding stock and young animals, its presence improves the physical properties of the litter, reduces labor costs and increases the productivity of chickens.

According to the degree of decomposition as a result of storage, litter bird droppings are divided into:

1. fresh - droppings that have not undergone microbiological decomposition;
2. slightly decomposed - litter, in which, as a result of microbiological processes, litter and feed residues have slightly changed color and strength;
3. semi-ripened litter, in which, as a result of microbiological processes, the litter and the remains of the feed have a dark brown color, lose strength and are easily torn;
4. rotted - litter, in which it is visually impossible to detect undecayed remains of plants and feed.

The nutrient content of an organic fertilizer based on high-quality bird droppings with strict observance of storage technology varies in accordance with its humidity. The following concentrations of nutrients were recorded in the absolutely dry matter of good quality bird droppings: nitrogen - 5.4-6.0%, phosphorus - 3.6-7.7 and potassium - 2.0-2.5

Thus, it can be concluded that organic fertilizers based on manure are effective on various soils when growing crops, and the authors [30-37] note that organic (biological) production methods in agriculture are certainly the future.

3 Experimental part

In their research, to analyze and diagnose the morphology and structure of the fertilizers obtained, they used the services of the Center for Collective Use "X-ray Diagnostics of Materials", which has scanning and transmission electron microscopy, a laser analyzer of ultrafine powders. The following devices were used to determine the elemental and phase composition:

-X-ray fluorescence element analyzer Spectroscan MAX-GV; manufacturer: NPO "Spektron", Russian Federation, year of issue: 2004.

-atomic absorption and compact desktop powder diffractometer D2 Phaser. Manufacturer: Bruker AXS, Germany; year of manufacture: 2011.

The following inorganic acids were used to treat the droppings:

Sulfuric acid is a very strong dibasic acid, at 18°C $pK_a(1) = -2.8$, $pK_a(2) = 1.92$ (K_2 1,2 10⁻²);

Orthophosphoric acid (phosphoric acid, chemical formula - H₃PO₄) is a chemical inorganic acid of medium strength, corresponding to the highest degree of phosphorus oxidation (+5).

Microbiological analyses were carried out in the laboratory of the Rosselkhoznadzor Republican Reference Center. Sanitary and bacteriological analyses were carried out for the presence of:

- Generalized coliform bacteria (OKB), including E.coli
- Pathogenic bacteria, including salmonella
- Enterococci (fecal)

At the same time used the following regulatory documents:

MUK 4.2.3695-21 - Methodical instructions. Methods of microbiological control of soil., item 4

MUK 4.2.3695-21 - Guidelines. Methods of microbiological control of soil., item 6

MUK 4.2.3695-21 - Guidelines. Methods of microbiological control of soil., item 5

3.1 Results of physico-chemical analyses

Chicken manure is a valuable organic fertilizer, contains all the basic elements of plant nutrition. However, fresh chicken manure has a viscous, sticky consistency and an unpleasant smell. If the storage technology is violated, chicken manure becomes a source of environmental pollution according to microbiological and parasitological indicators.

Of all types of organic fertilizers, poultry manure is the most valuable in terms of the content of nutrients and their availability to plants (Table 3). Chicken manure contains more phosphorus, nitrogen and potassium than cattle and pig manure (the table provides a comparative characteristic).

Table 1. Chemical composition of manure and bespodstilochny manure, %

Composition	Chicken droppings		Cattle	Pigs
	raw	thermally dried		
Dry matter	36,0	83,0	10,0	9,8
Nitrogen	2,10	4,54	0,43	0,72
Phosphorus, P ₂ O ₅	1,44	3,65	0,28	0,47
Potassium, K ₂ O	0,64	1,74	0,50	0,21

A comparative assessment of the content of nutrients in cattle manure and chicken manure indicates a significant superiority of the latter.

The concentration of nitrogen is 3.6 times higher, phosphorus - 2.3, potassium - 1.7, calcium - 6, magnesium - 6.7 times. There are also many trace elements in bird droppings. 100 g of its dry matter contains (mg): iron 367-900; zinc 12-39; manganese 15-38; copper - 0.5; cobalt 1-1.2. The main amount of these elements is in a water-soluble form.[4-7]

Table 2. Types of manure and methods of its disinfection.

Name	Disinfection methods		
	biological	chemical	physical
Litter	Composting, long-term aging	-	drying
Litter with litter	Biothermic, long-term exposure	-	Accelerated composting by intensive air ventilation

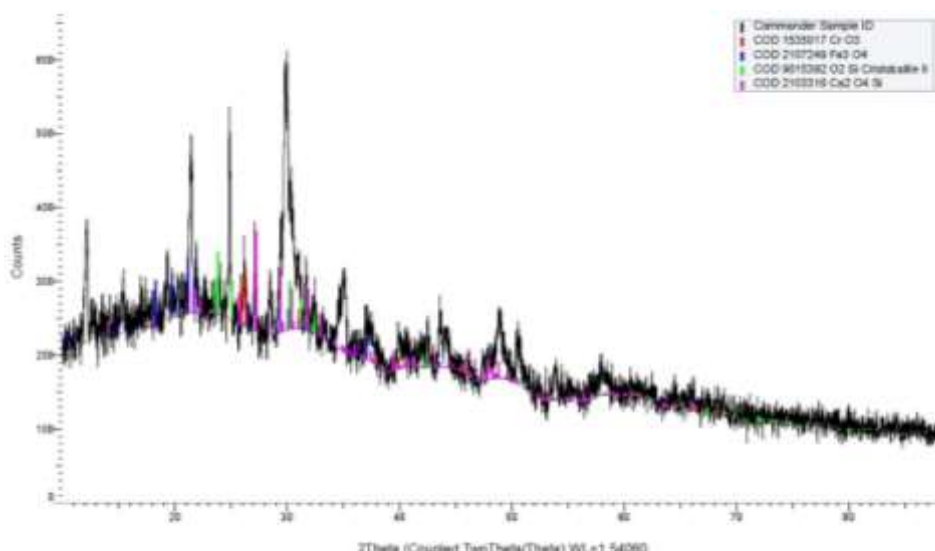


Fig. 1. Results of X-ray fluorescence elemental analysis of acid-treated droppings.

Having studied the existing methods of manure processing, we found that chemical methods are practically absent. Therefore, the development of methods to accelerate the processing of chicken manure into organic fertilizers will not only reduce the shelf life of animal waste, but also obtain high-quality organic fertilizer, reduce the cost of mineral fertilizers.

Show	Icon	Color	Index	Name	Parent	Scan	Pattern #	Compound Name
Yes			1	COD 1535017	Pattern List #1	1.brml #1	COD 1535017	
Yes			2	COD 2107249	Pattern List #1	1.brml #1	COD 2107249	
Yes			3	COD 9015392	Pattern List #1	1.brml #1	COD 9015392	Cristobalite II
Yes			4	COD 2103316	Pattern List #1	1.brml #1	COD 2103316	

Formula	Quality	Y-Scale	I/Ic DB	I/Ic User	S-Q	Concentration Level	Added Reference
Cr O3	Quality Unknown	21.38 %	3.180	0.000	9.4 %	Major	
Fe3 O4	Quality Unknown	20.36 %	3.170	0.000	9.0 %	Major	
O2 Si	Quality Unknown	22.33 %	0.980	0.000	31.8 %	Major	
Ca2 O4 Si	Quality Unknown	35.73 %	1.000	0.000	49.9 %	Major	

Fig. 2. Physico-chemical analyses showed that fresh manure, in terms of dry matter, contains up to 35.6% crude protein, 14.3% crude fiber, 5% fat and 16.6% ash.

Table 3. Chemical composition of fresh bird droppings, %

Type of bird droppings	N	P ₂ O ₅	K ₂ O	CaO	MgO
Chicken	1,63	0,54	0,85	2,40	0,74

An acid solution is used to process fresh bird droppings. Acid, when interacting with organic matter, partially destroys its easily hydrolyzable fraction, reducing the agronomic value of fertilizer and increased acidity can negatively affect soil fertility. Therefore, a suitable concentration was selected.

The use of acid makes it possible to change the nature and ratio of gases emitted by fresh droppings, thereby significantly reducing the environmental burden on the environment.

The method of processing sulfuric and orthophosphoric acids is carried out as follows.

Table 4. The total content of trace elements in the samples before and after acid treatment.

Indicator	Content mg/kg						
	fresh chicken droppings				fresh chicken manure treated with inorganic acids		
	Sample №1	Sample №2	Sample №3	average result	Orthophosphoric acid	Sulfuric acid	average result
Ammonium ions	7000	6600	6120	6573	9120	9360	9240
Cadmium	0,16	0,8	0,6	0,52	0,33	0,1	0,215
Arsenic	<0,1	8,3	0,8	3,06	<0,1	1,1	0,6
Nickel	3,6	7,8	4,9	5,43	3,8	3,9	3,85
Lead	<1	1,2	4,8	2,34	<1,2	2,9	2,05
Sulfates	6458	6508	6478	6481	7900	8275	8087
Chrome	2,3	7,6	3,4	4,43	1,2	2,1	1,55
Zinc	102	225	306	211	124	287	205
pH (unit pH)	7,8	8,9	8,1	8,26	6,5	6,9	6,7

When using modern methods of keeping poultry in cages with automatic climate maintenance, the humidity of the litter is 60-65%. At the specified humidity, one ton of manure is mixed for 10-15 minutes with 60-53 liters of a 25% solution of sulfuric or phosphoric acid or with 40-46 liters of a 35% solution of sulfuric or phosphoric acid, while pH values of 6.5 to 7.5 units are reached.

After processing, the content of trace elements in the samples increased the nitrogen content due to its binding in the form of soluble salts.

3.2 Results of microbiological analyses

Chicken manure is a valuable organic fertilizer, contains all the basic elements of plant nutrition. However, fresh chicken manure has a viscous, sticky consistency and an unpleasant smell. If the storage technology is violated, chicken manure becomes a source of environmental pollution according to microbiological and parasitological indicators.

Table 5. Results of microbiological analysis.

№	The name of the indicator	unit of measurement	Test result of untreated chicken manure	Test result of processed chicken manure	standard	ND on the test method
Sanitary and bacteriological indicators						
1	Generalized coliform bacteria (OKB), including E.coli	r	300 cells/g	Not detected in 1 g	Not detected	MUK4.2.3695-21 - Methodical instructions. Methods of microbiological control of soil., item 4
2	Pathogenic bacteria, vt.h. salmonella	r	170cells/g	Not detected in 1 g	Not detected	MUC 4.2.3695-21 - Guidelines. Methods of microbiological control of soil., item6
3	Enterococci (fecal)	r	500 cells/g	Not detected in 1 g	Not detected	MUC 4.2.3695-21 - Guidelines. Methods of microbiological control of soil., item 5

During the tests, fertilizers were obtained that do not contain pathogenic microflora. The use of inorganic acids, such as sulfuric or orthophosphoric, can be recommended for use for processing fresh chicken manure into fertilizer and complies with GOST [8]. Appendix 1 contains the ROSSELKHOZNADZOR test report.

4 Conclusion

The disadvantages of the known methods of processing litter are:

1. duration of the process (composting up to 10-16 months, method
2. accelerated fermentation – up to 3-4 weeks);
3. when the pH of the bird droppings environment increases by more than 7 units, free ammonia is released, which leads to a loss of nitrogen;
4. in order to prevent ammonia emissions into the environment, it becomes necessary to use special installations for its capture.

In our case, the result is achieved by treating the litter with mineral acids. The use of acid makes it possible to change the nature and ratio of gases emitted by fresh droppings, thereby significantly reducing the environmental burden on the environment

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