Method of obtaining pure organo-mineral fertilizer and its ecological investigation of the influence on soil fertility

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Abstract. The article discusses the soil-improving properties of an environmentally friendly organo-mineral fertilizer (OMF) obtained on a scientific basis at the Institute of Chemistry of the Academy of Sciences of Turkmenistan. The main goal of the study is to obtain an environmentally friendly OMF from chicken manure, which accumulates in large quantities on poultry farms and pollutes the environment, as well as to study the effect of the resulting fertilizer on the humus composition of the soil. Broiler chicken manure, microbiological preparation Nourivit Plus and phosphorite ores from the deposit of the Magdanly-Kugitan region of the Durnaly site were used as raw materials and their chemical compositions were determined (humidity, ash content, total organic matter, total nitrogen, phosphorus, and potassium and pH environment). The composition of bird droppings was found to contain a sufficient amount of organic substances and such important nutrients as nitrogen, phosphorus, and potassium. Under laboratory conditions, a scientific method for obtaining an environmentally friendly OMF was studied. Chicken manure used as raw material was neutralized from weed seeds and helminth eggs. Processing on the basis of waste-free technology of waste generated in poultry farms, an environmentally friendly, cost-effective, soil-improving OMF was obtained. The soil-strengthening properties of the obtained OMFs were studied at the Turkmen Agricultural University named after SA Niyazov on 3 plots of agricultural land measuring 1 x 6 meters. Samples were taken for analysis from each of the 3 soils before and after the application of OMF. An agrochemical analysis of the soil and a quantitative analysis of substances soluble in it were carried out. As a result, the elemental and humus composition of soil samples was determined before and after fertilization, and as a result it was proved that it is possible to increase the amount of humus in the soil from 0.12% to 2.17%.

Keywords. Chicken manure, organic waste processing method, organic fertilizer, chicken manure processing, environmentally friendly fertilizer, phosphorite ore, increasing soil humus.

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1 Introduction

Modern environmental problems are associated with the accumulation of a large amount of animal waste (poultry droppings, cattle and pig manure) [1]. If enterprises use unprocessed manure and other animal waste in their production, they pollute the soil with helminths, pathogenic microorganisms and toxic chemical compound [2]. In recent years, there has been a steady decrease in the content of humus in the soil, which reduces the productivity of the soil, and also worsens its physical, chemical and physico-chemical properties [3].

Bird droppings, in turn, are one of the important issues in the field of environmental protection. In terms of content, it belongs to the 3rd class of toxicity. When processing bird droppings, the level of its toxicity is brought to the 5th class after the extraction of the poisonous gases contained in it [4, 5] and it is used as an environmentally friendly organo-mineral fertilizer (OMF) in agriculture [6].

The scientific data available in the world practice [7] give an idea of the design and operation rules of large-scale biogas plants for industrial use [8]. Scientists from the Institute of the Sun of the Academy of Sciences of Turkmenistan studied methods for obtaining biogas and manure fertilizers using bioreactors at biogas plants equipped with solar collectors, which process manure from livestock and poultry farms without waste [9, 10]. When biogas is obtained by processing bird droppings, nitrogen in its composition leaks out, and this also requires a long time up to 90 days.

In our scientific work, we propose a method for obtaining environmentally friendly OMFs by processing bird droppings available in all areas of agriculture according to technological drawings using a simple technology.

The objectives of the study are: the study of the chemical composition of chicken manure and natural phosphorite, the study of methods for processing chicken manure into an environmentally friendly organic fertilizer, as well as the study of the effect of the resulting fertilizer on soil fertility.

2 Materials and Methods

The Institute of Chemistry of the Academy of Sciences of Turkmenistan, together with the Turkmen Agricultural University named after S.A. Niyazov, as a result of research work on the topic “Effective and economical production of environmentally friendly OMFs in agriculture”, developed in the laboratory on a scientific basis in the accredited department of “Physical and chemical analyzes and certification” of the Institute of Chemistry of the Academy of Sciences of Turkmenistan, a method for obtaining environmentally friendly OMF. The purpose of this study is to obtain an environmentally friendly OMF from chicken manure, which accumulates in large quantities on poultry farms and pollutes the environment, as well as to study the effect of the resulting fertilizer on the humus composition of the soil.

Chicken manure of chickens of the Broiler breed, microbiological preparation Nourivit Plus and phosphorite ores from the deposit of the Magdanly-Kugitan region of the Durnaly site [5] were used as raw materials, and their chemical compositions were determined. Moisture was tested using the methods described in regulation TDS-26713-85, ash according to TDS-26714-85, total organic matter according to TDS-26213-91, phosphorus as P_2O_5 according to TDS-26717-85, total nitrogen according to TDS-26715- 85, K_2O according to TDS 26718-85, pH medium according to TDS-27979-88. The composition of bird droppings ash was studied on an EPSILON-3 XL X-ray fluorescence energy-dispersive spectrometer, which performs fluorescence analysis, and a Zeenit-700 P atomic absorption spectrometer.

3 Results

The data obtained as a result of the research are presented in Table 1.

Table 1. Chemical composition of chicken manure.

#	Samples	Moisture, %	Ash content, %	General organics, %	N, %	P_2O_5, %	K_2O, %	pH
1	Chicken manure #1	17.57	17.33	82.67	4.074	1.80	2.90	7.23
2	Chicken manure #2	17.33	17.26	82.74	4.086	1.54	3.00	7.19
3	Average	17.45	17.30	82.70	4.08	1.67	2.95	7.21

As can be seen from Table 1, bird droppings contain organic substances, such important elements for plants as nitrogen, phosphorus and potassium. The content of metal oxides in the composition of bird droppings was determined on the basis of a fluorescence analysis of the ash obtained by burning bird droppings at a temperature of 850-900^{0}C. The data obtained are shown in Table 2.

Table 2. Chemical composition of chicken manure ash (fluorescent analysis).

#	Name of element oxides	Research results, %	#	Name of element oxides	Research results, %
1	MgO, %	2.406	10	SO_3, %	4.326
2	Al_2O_3, %	0.430	11	NiO, %	0.020
3	SiO_2, %	3.315	12	CuO, %	0.087
4	K_2O, %	19.334	13	MoO_3, %	0.009
5	CaO, %	53.778	14	SrO, %	0.037
6	Cr_2O_3, %	0.007	15	SnO_2, %	0.027
7	MnO, %	0.598	16	PbO, %	0.002
8	Fe_2O_3, %	2.252	17	Cl-,%	3.344
9	P_2O_5, %	9.686	18	Br-,%	0.006

As can be seen from Table 2, 100 grams of bird droppings contain mainly 53.778% calcium oxide, 19.334% potassium oxide and 9.686% phosphorus oxide.

In accordance with the requirements for OMFs, taking into account the sufficient content of nitrogen, phosphorus, potassium (NPK) and organic substances in the composition of bird droppings, a method for obtaining environmentally friendly OMF was studied on a scientific basis in laboratory conditions. This method is distinguished by the use of simple technology, economy and ease of use in all agricultural associations. In the course of experimental work, the raw materials were first treated with the microbiological preparation Nourivit Plus. Nourivit Plus is a fermentation product made from Nourivit Plus microorganisms – NPM (*Bifidobacterium animalis*, *Bifidobacterium bifidum*, *Lactobacillus fermenum*, *Lactobacillus casei*, *Lactobacillus plantarum*, *Rhodopustacrecare* and *Saccharomyces cerevisiae*). This preparation does not contain genetically modified microorganisms. Nourivit Plus was added in the amount of 1 liter per 1 m^3 of bird droppings and provided good moisture. Aeration was carried out by mixing the substrate every other day for 2 weeks. The ripening process itself is 1 month including the aeration of the substrate. Then, phosphorite flour (particle size no more than 1.0 mm) was added to the resulting substrate in a ratio of 0.3/0.5:1, and thoroughly mixed. The resulting fertilizer was then granulated and dried. The full composition of the OMF in the form of granules was studied. The data obtained are shown in Table 3.

Table 3. Chemical composition of granular OMF (OMF).

#	Samples	Moisture, %	Ash content, %	General organics, %	N, %	P_2O_5, %	K_2O, %	pH
1	OMF #1	7.24	21.50	78.50	4.07	3.40	2.20	6.78
2	OMF #2	6.77	21.40	78.60	4.03	3.46	2.18	6.80
3	OMF #3	6.37	21.75	78.25	4.02	3.43	2.21	6.74
4	Average	6.79	21.55	78.45	4.04	3.43	2.19	6.77

As can be seen from Table 3, the average content of substances useful for plants in the composition of OMF is approximately as follows: organic matter - 78.45%, nitrogen - 4.04%, phosphorus (in the form of P_2O_5) - 3.43 %, potassium (in the form of K_2O) -2.19%, which meets the requirements for organic fertilizers. To study the content of metal oxides in organic fertilizer from bird droppings, the obtained fertilizer was burned at a temperature of 850-900^{0}C, its ash was determined on the basis of fluorescent analysis. The data obtained are shown in Table 4.

Table 4. Quantity of metal oxides in OMF (fluorescent analysis).

#	Name of element oxides	Research results, %	#	Name of element oxides	Research results %
1	MgO, %	0.34	9	P_2O_5, %	4.19
2	Al_2O_3, %	1.05	10	SO_3, %	1.41
3	SiO_2, %	5.66	11	NiO, %	0.006
4	K_2O, %	3.93	12	CuO, %	0.002
5	CaO, %	17.58	13	MoO_3, %	0.004
6	Cr_2O_3, %	0.10	14	ZnO, %	0.16
7	MnO, %	0.20	15	PbO, %	0.002
8	Fe_2O_3, %	5.89	16	Количество хлорида, Cl-,%	0.25

Looking at the data in Table 4, we can say that the content of heavy metal oxides in the organic-mineral fertilizer obtained from bird droppings does not exceed the maximum permissible concentration.

The soil-improving property of an environmentally friendly OMF obtained on a scientific basis in laboratory conditions was scientifically studied on 3 plots with an area of 1 x 6 meters of an agricultural site on the territory of the Turkmen Agricultural University named after S.A. Niyazov (Figure 1).

Figure 1. Experimental site of the Turkmen Agricultural University

When carrying out research work in the conditions of the agro-site, samples were first taken from the soil of each of the selected 3 plots for chemical analysis. In the accredited department of "Physical-chemical analyzes and certification" of the Institute of Chemistry of the Academy of Sciences of Turkmenistan, the soil taken was subjected to agrochemical analysis, the results of which determined the content of humus, total nitrogen, total P_2O_5, total K_2O in %, nitrogen-containing NO_3 ions - and NH_4^+, active P_2O_5 in mg/kg, as well as the pH value. By carrying out a quantitative analysis of water-soluble substances in the composition of the soil taken, the percentage of dry residue, anions (CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, Σ) and cations (Ca^{2+}, Mg^{2+}, $\Sigma Ca^{2+} + Mg^{2+}$, $\Sigma Na^+ + K^+$, Σ). The data are given in Table 5.

Table 5. Soil analyzes in 2022.

Agrochemical analysis of soil sample #1								
Samples	Humus	N	P_2O_5	K_2O	N, mg/kg		P_2O_5, mg/kg	pH
	%				NO_3	NH_4		
13.01	0.55	0.14	0.028	5.14	-	18.00	-	7.64
27.04	1.62	0.14	0.031	1.78	38.00	48.00	14.00	6.842

Amount of dissolved substances according to the sample #1											
Samples	TDS, %	Anions, %					Cations, %				
		CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Σ	Ca^{2+}	Mg^{2+}	ΣCa+Mg	ΣNa+K	Σ
13.01	0.5	-	0.33	0.002	0.12	0.452	0.02	0.009	0.029	0.02	0.049
27.04	0.49	-	0.33	0.003	0.09	0.443	0.03	0.01	0.04	0.007	0.047

Agrochemical analysis of soil sample #2								
Samples	Humus	N	P_2O_5	K_2O	N, mg/kg		P_2O_5, mg/kg	pH
	%				NO_3	NH_4		

13.01	0.45	0.14	0.033	2.66	-	13.33	-	7.67
27.04	1.92	0.18	0.037	2.83	37.50	32.00	12.40	6.752

Amount of dissolved substances according to the sample #2

Samples	TDS, %	Anions, %					Cations, %				
		CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Σ	Ca^{2+}	Mg^{2+}	ΣCa+Mg	ΣNa+K	Σ
13.01	0.6	-	0.30	0.002	0.20	0.502	0.05	0.015	0.065	0.033	0.098
27.04	0.50	-	0.30	0.003	0.13	0.433	0.04	0.02	0.05	0.017	0.067

Agrochemical analysis of soil sample #3

Samples	Humus	N	P_2O_5	K_2O	N, mg/kg		P_2O_5, mg/kg	pH
	%				NO_3	NH_4		
13.01	0.12	0.11	0.02	1.88	-	10.50	-	7.91
27.04	2.17	0.21	0.04	1.32	40.00	60.00	21.40	6.664

Amount of dissolved substances according to the sample #3

Samples	TDS, %	Anions, %					Cations, %				
		CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Σ	Ca^{2+}	Mg^{2+}	ΣCa+Mg	ΣNa+K	Σ
13.01	0.38	-	0.30	0.002	0.05	0.352	0.012	0.004	0.016	0.012	0.028
27.04	0.54	-	0.40	0.003	0.07	0.473	0.028	0.015	0.043	0.024	0.067

To introduce into the soil of 3 sections of the agricultural site on the territory of the Turkmen Agricultural University named after S.A. Niyazov, according to the method developed in the laboratory, at the Institute of Chemistry of the Academy of Sciences of Turkmenistan, the required amount of environmentally friendly OMF was prepared (Figure 2).

Figure 2. Obtaining OMF.

Then the prepared OMF was applied to the soil of 3 plots. Watering, plowing were carried out regularly: once a week (Figure 3).

Figure 3. Agro-field with applied fertilizer.

For chemical analysis, three months later, soil samples were taken from each of the 3 sections of the agricultural site. A chemical analysis of soil samples was carried out, as well as a quantitative analysis of water-soluble soil substances. The data are given in Table 5.

As a result of the analyzes, it was found that the humus content in the soil of the first plot increased from 0.55% to 1.62%, the second plot increased from 0.45% to 1.92%, the third plot increased from 0.12% to 2.17%. The results of the research work carried out have shown that an environmentally friendly OMF has the ability to enrich the soil with humus.

4 Discussion

Processing on the basis of waste-free technology of waste generated in poultry farms, an environmentally friendly, cost-effective, soil-improving OMF was obtained. Unlike other processing methods, this chicken manure processing method is the most cost-effective. The process of processing raw materials into finished fertilizer takes much less time and costs than other methods of processing chicken manure.

Taking into account the sufficient content of nitrogen, phosphorus, potassium (NPK) and organic substances in the composition of bird droppings in the laboratory, a method for obtaining environmentally friendly OMF was studied on a scientific basis. This method is distinguished by the use of simple technology, economy and ease of use in all agricultural associations.

The average content of substances useful for plants in the composition of OMF (OMU) is approximately as follows: organic matter - 78.45%, nitrogen - 4.04%, phosphorus (in the form of P_2O_5) - 3.43%, potassium (in the form of K_2O) -2.19%. The content of heavy metal oxides in the OMF obtained from bird droppings does not exceed the maximum allowable concentration.

The soil-strengthening properties of the obtained OMFs were studied at the Turkmen Agricultural University named after S.A. Niyazov on 3 plots of agricultural land measuring 1 x 6 meters. As a result of the analyzes, it was found that the humus content in the soil of the first plot increased from 0.55% to 1.62%, the second plot increased from 0.45% to 1.92%, the third plot increased from 0.12% to 2.17%. The results of the research work carried out have shown that an environmentally friendly OMF has the ability to enrich the soil with humus.

5 Conclusion

As a result of research work, the following conclusions were drawn:

1) Using analytical methods in laboratory conditions, the main agrochemical indicators of chicken manure and phosphorite ore were studied;

1) In laboratory conditions, on a scientific basis, a method has been developed for obtaining environmentally friendly OMF using local raw materials (bird droppings and phosphorite ore);

2) Weed seeds, helminth eggs were disinfected as part of bird droppings used as raw materials;

3) Through the use of the microbiological preparation Nourivit Plus, it was possible to prevent the loss of total nitrogen;

4) By processing bird droppings - a harmful waste generated on poultry farms, on the basis of waste-free technology, an environmentally friendly, cost-effective, soil-improving OMF was obtained;

5) The properties of environmentally friendly OMF, enriching the soil, obtained in laboratory conditions on a scientific basis, were studied;

6) The results of the conducted researches have shown that the environmentally friendly OMF has a high ability to improve the soil.

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