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BIOTECHNOLOGICAL PROCESSING OF ORGANIC POULTRY WASTE AND ITS USE IN AGRICULTURE

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ABSTRACT

Up-to-date biotechnologies are involved in the biological transformation of organic poultry waste into an environmentally friendly fertilizer that can preserve soil fertility and significantly improve yields. Currently, no more than 35% of livestock manure is used as a fertilizer in Uzbekistan.

The use of poultry manure at poultry farms in Uzbekistan has been poorly addressed today. Poultry manure is discarded outside the poultry farms, where it is either filled with pits not suitable for storage or unloaded in a specially designated area. Afterwards, it is not used and causes tremendous damage to the environment. At the same time, bird droppings contain high macro and microelements, which form the basis for their value as organic fertilizers.

***The article analyzes** and summarizes the practical use of biotechnological processing of bird droppings into a fertilizer and its further application on strawberry seeds as one of the reasonable solutions to the economic and environmental safety of poultry production under industrial conditions.*

***The relevance of the topic.** The solution to the problem of manure recycling is to improve the environmental situation, soil fertility and crop yields.*

***The research is aimed at** processing organic poultry waste and the impact of organic fertilizer, which is based on chicken manure, on soil fertility and crop yields.*

***The laboratory and field studies** on poultry waste management have been carried out on the territory of OOO Silver Eagle Plus (LLC) poultry farm in Tashkent region using the method of anaerobic fermentation and assessment of organic fertilizer quality as the most rational one for agriculture.*

***The studied objects** have been organic waste from OOO Silver Eagle Plus (LLC) poultry farm in Tashkent region, meadow soil and Joydori strawberry seeds.*

***The research results** have shown that the method of methane digestion is effective against pathogens in organic poultry waste; the process increases the number of useful bacteria and the generation of metabolites such as organic acid. Biotechnological poultry waste disposal reduces the processing time of the source material by 1.5 times.*

***The study has revealed** that the application of organic fertilizer based on chicken droppings has had a positive impact on soil structure, which has enhanced its aeration and ensured proper vegetative root system development.*

KEYWORDS: *biotechnological processing, poultry farming, organic waste, anaerobic digestion, biofertilizer, soil fertility, ecology.*

INTRODUCTION

For combating the environmental issues in Uzbekistan, it is worth paying attention to the operations of poultry farms, organic waste of which should be promptly processed by biotechnological methods. Organic poultry waste includes bird droppings, low-value feathers, blood and organs, which represent an aggressive substance that contains a vast number of harmful microorganisms such as disease-causing bacteria, helminth eggs, larvae, and weed seeds; besides, it has an unpleasant odour.

In the past, under intensive farm management cows with small dairy production and chickens were kept primarily for manure. The concentration of cattle or bird per unit of land was minimal. Manure was accumulated near the farms or taken to fields, where it gradually turned into humus.

Today, this method of application raises several problems. Firstly, the transportation of a vast amount of sewage (the content of dry matter 2-5%) requires a lot of money. Secondly, soil, underground and surface waters are infected with invasive, toxic elements. Thirdly, it leads to concentration of nitrates, copper and zinc in grain, grass and water resources. As a result, some U.S. states, for example, have banned the application of unprocessed bird droppings as a fertilizer [1].

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Biotechnological disposal using methane digestion, thus, is one of the right solutions for recycling poultry waste. Raw materials, gained with the help of this process, can be widely used in agriculture as an environmentally friendly fertilizer, methane, animal feed additives and fuel gas.Like any other biological process, composting needs some factors to ensure satisfactory results, including the most important ones: temperature, moisture, pH and chemical composition of the material; the latter is the most challenging to be controlled and thus leads to varied results during the process **[2].** (Orrico Junior et al., 2010). Huang et al. (2008) and Perez et al. (2002) showed that the composition of the fibrous fraction of plant materials (cellulose, hemicellulose and lignin) significantly influences the degradation rate of these compounds, mainly when the lignin comprises the major part of the substrate **[3].**

The article provides studies on the production of high-quality organic fertilizers while production of other processed products requires more resources and costs.

WHY CHICKEN MANURE?

According to statistics, one poultry farm in Uzbekistan annually throws out up to 6000-7000 tons of bird droppings. During a year one chicken gives 6-7 kg of dung **[4].** The poultry farm "Silver Eagle Plus" LLC, where the research has been carried out, receives about 8640 tons of poultry waste per year. The poultry farm with 10 thousand chickens produces 2 tons of excrements per day **[5].** Fresh manure contains about 76% water. 1000 hens produce 65 tons of fresh manure, on the dry basis as sold (approximately 30% water), 25 tons is produced by 1000 hens per year **[6]**.

The utilization of organic masses in such amounts is problematic for poultry farms, bird droppings are accumulated near them, lose their valuable qualities and pose a serious ecological threat to the environment.

Fresh chicken droppings contain 1.5-2.5% nitrogen, 1-2% phosphorus and about 1% potassium (Table 1).

Table 1: Chemical composition of bird droppings, %

Manure	H_2O	N	P_2O_5	K_2O	CAO	MGO	SO_3
Chicken	56	1,6	1,5	0,8	2,4	0,7	0,4

Its chemical composition is 3-4 times richer than cattle manure. Poultry manure contains the following chemicals (Table 2) **[7]**:

Table 2: Chemicals found in poultry manure

- manganese - zinc - cobalt - copper - iron - nitrogen	- potassium - magnesium - phosphoric acid - boron - brimstone

The amount of these substances depends on the diet and the way the chicken is kept as well as its age. Fresh manure contains no more than 40% water. Its acidity does not exceed 7 pH.

According to Averyanov, the Russian scientist, the dung contains microelements: 100 g of dry matter contains 15-38 mg of manganese, 12-39 mg of zinc, 1-1.2 mg of cobalt, 1-2.5 mg of copper and 300-400 mg of iron **[8]**. Most of the food elements in bird droppings are in water-soluble form.

Drying of chicken droppings in cage rearing takes about 8 hours 10-12%, in 12 hours - 13-16%, in a day - 27-32%. Bedding manure is obtained at the floor rearing, drying of which is faster, reaching 50% in 12 hours.

Chicken manure as a source of plant nutrients has long been recognized around the globe. Besides being a valuable source of plant nutrients, chicken manure is a significant soil conditioner, and it enhances the soil's moisture-holding and nutrient-holding capacities. Due to the high concentration of organic components and their gradual release, the effect on the harvest can be observed in the next 2 or 3 years.

Many farmers do not use the manure as a fertilizer because they do not know how to use it properly. When stored in large piles, bird droppings heat up and release ammonia that evaporates quickly. In 2-3 months, nitrogen losses may reach 30-50%. Different methods of treatment are used to reduce the loss of nutrients when storing the manure.

BIOTECHNOLOGICAL PROCESSING METHODS OF POULTRY WASTE

Cleared or flushed droppings can cause problems unless they are processed instantly into something useful or valuable. Fresh dung, as well as the liquid released from it, kills the insects living in the soil without which the regeneration of soil is impossible.

According to the World Health Organization (WHO), litter and sewage of poultry farms can be the driving force behind the transmission of more than 100 agents of infectious and invasive diseases, including zoonosis **[9]**. Besides, the organic waste itself

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can serve as a favourable habitat for the development and long-term survival of pathogenic microflora, contain increased amounts of heavy metals, pesticides, drugs, radioactive substances, weed seeds and other contaminants.

Under the Decree of the President of the Republic of Uzbekistan of 13.11.2018, N PP-4015, "On additional measures for further development of poultry farming" considering the existing problems that impede the further development of the sphere, one of which is a low level of poultry waste processing, to take measures to set production of equipment, inventory, and mechanisms necessary for production and processing by the end of 2022 **[10]**.

Organic fertilizers derived from manure should be free from pathogenic microorganisms, resilient eggs and helminth larvae. The efficiency of organic fertilizer decontamination is monitored using microbiological methods to ensure the survival of indicator (sanitary) microorganisms: bacteria of E. coli group, staphylococcus and spores following the instruction on laboratory control of treatment facilities at animal breeding complexes, instructions for veterinary disinfection of livestock facilities and veterinary and sanitary rules of preparation to be used as organic manure fertilizers, manure and effluents for infectious and invasive diseases of animals and poultry **[11]**.

Decontamination of organic waste is considered to be effective in the absence of a 10 g (cm3) sample of E. coli, staphylococcus, enterococcus or aerobic spore-forming microorganisms, depending on the type of infectious agents in a triple study.

Bacteriological and parasitological control of manure as well as compost based on it is conducted by specialists from veterinary laboratories.

The current technological level of the poultry industry requires an innovative approach to the processing of bird droppings and the production of organic fertilizers from them, the essence of which is the introduction of low-waste technologies.

There are several ways to process organic poultry waste:

- aerobic fermentation;

Straw or peat is interspersed with droppings and rots in warm weather for a month and a half. This method requires special sites, techniques and large quantities of peat, straw and other materials that reduce moisture. If the technology is followed, good quality biohumus is obtained, but up to 30-40% of nutrients are lost as gases. Peat is poured on the site with a layer of 30-40 cm (using loaders, tractor trailers, spreaders, dump trucks), on top of it - dung (with a moisture of 75% and peat 65% ratio 1:1). Then everything is stirred and a storage clamp is formed using a bulldozer. The width of the compost clamp is 3-4 m, height is 2 m, length is at least 6-8 m. The top of the storage clamp is covered with peat. During the cold season the compost is kept for two months, during the warm season - for one month. Shredded straw or sawdust as bedding in factories can be a reliable method of preserving nitrogen in the manure. Sometimes additional enzymes are added to the compound to accelerate rotting and fermentation. Adding 6-10% superphosphate or about 20-30% soil to the manure before storing will prevent nitrogen loss **[12]**. It should be stored in a dry place to reduce losses. In order to obtain proper fermented manure, it is necessary to stir it from time to time. This will improve the flow of oxygen and atmospheric nitrogen to the inner layers of the pile, so that the bacteria will perform their work more efficiently.

The main disadvantages: it is impossible to use the area, which is planned for planting in the next 3-5 years, because the liquid flowing from the pile not only kills worms and other earthlings, but also greatly changes the chemical composition of the soil, causing its infertility; it is necessary to remember that prolonged storage leads to a deterioration of its properties; use without special training and treatment can cause damage, when applied in a pure form under the potatoes, etc.. When applied in its pure form under potatoes, etc., root vegetables can worsen their taste (it is recommended to apply in autumn and only in the form of compost); during rotting, gases and ammonia are released into the atmosphere.

- drying;

During the drying process, moisture is removed from the dung by various means, at least to the point where the bacteria completely stops its activity. Primary dehydration is carried out using a separator that reduces the moisture content to 50-70%. The material is then either turned into granules and dried with a drum dryer, or immediately fed into a drum dryer, which reduces moisture to 15-30%. Due to the high temperature, pathogenic bacteria as well as worms in any form are killed during the processing. Drying of dung is used to make dry pellets for fertilizer (dried manure) or fuel for solid-fuel heaters and heating devices.

Disadvantages: it is essential that the dry material is immediately packaged in an airtight polyethylene package, and the air in the package must also contain a minimum of moisture. Despite the fact that previously all bacteria have died, they are in the air, and under these conditions they will reproduce quickly.

- vermiculture;

The technology of preparing vermicompost (getting biohumus) on the basis of bird droppings is carried out by rearing the red Californian worm and other rainworm subspecies (E. foetida) in the prepared compost. Substrates for vermicomposting are preliminary prepared by biothermal treatment and then used according to the adopted technology **[13]**.

Vermicomposting is carried out in the places with a set of technological equipment that provides optimal parameters of the atmosphere (temperature 20 ± 2.5 ° C, humidity of the compost mass - not more than 70 %, pH - 7.0 ± 0.5) for the uterine vermiculture, which is introduced into the compost in the amount of 30-50 specimens per 1 kg of substrate **[14]**. Vermicompost is ready to be consumed in 4-5 months after laying the California worm in the substrates.

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Disadvantages: the process requires a lot of time and several processes; before adding the worms to the litter, it should already be processed by one of the existing methods.

- anaerobic digestion

This method solves several tasks at once: collection and processing of poultry farm waste with the capture and neutralization of harmful biogas, obtaining environmentally friendly fertilizers, as well as methane for mini combined heat and power unit, fuel gas for motor vehicles, ensuring the operation of a freon-free cooler, production of "dry" ice, soda, etc. **[15]**. In 1998, there were more than 800 (including 24 large) bioenergy plants operating on manure in Europe **[16]**. In China, India and other Asian countries there are more than 3 million of them. The application of the technology is constrained by the lack of investments, as well as the absence of basic structures. This method is also used to produce biogas, which is released during the processing of organic waste. As a result of biogas production, the remaining waste contains 2-4 times more basic nutrients than conventional organic fertilizers. In addition, the organic substance produced by this method contains more humic acids, plant growth stimulants, vitamins, amino acids, etc. The biofertilizer obtained by this method is of the highest quality, and the generated methane can be used as a fuel and energy source.

Disadvantages: biogas is convenient for obtaining biohumus and fuel in the private sector, but requires a capital investment and technological improvements.

Organic fertilizer obtained by anaerobic fermentation on the territory of the poultry farm in Tashkent region

Silver Eagle Plus LLC (OOO) poultry farm in Tashkent region has 6 poultry houses with cage rearing. 4 poultry houses for 120000 heads, which work at full capacity, produce up to 24 tons of manure per day (Table 3). According to M.M. Tashkuziev each chicken is capable of producing about 150-200 g of litter per day **[17]**.

Table 3: Calculation of bird droppings produced by four houses per day

Numberofheads	Droppings (average, day/year)	Total (day/t.)
120000	200	24

Table 4: Calculation of bird droppings received by four poultry houses monthly

Amount of bird droppings (day/t.)	Numberofdays (month)	Total (month/t.)
24	30	720

Table 5: Calculation of bird droppings received by four poultry houses annually

Amount of bird droppings (month/t.)	Numberofmonths (year)	Total (year/t.)
720	12	8640

Thus, 4 poultry houses of Tashkent poultry farm "Silver Eagle Plus" LLC produce up to 720 tons per month and 8640 tons per year respectively (Table 3, Table 4).

Two experiments have been conducted on the territory of the poultry farm under the leadership of the poultry farm manager AsadovI.M.. Straw, tree leaves, sawdust and water in the first experiment have been used in equal quantities as a filler. In the second experiment, no additional organic materials have been employed besides water.

During the tests, it has been found that the smaller the part of the substrate, the better. The larger the interaction area for bacteria and the more fibrous substrate, the easier and faster it is for the bacteria to decompose the substrate. In addition, it is easier to stir, mix and heat without creating a floating crust or sediment. Grinded raw materials have an impact on the amount of gas produced through the duration of the fermentation period. The shorter the fermentation period, the better the material has to be crushed.

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METHANE DIGESTION PROCESS

Methane digestion with free methane emission:

Organic compounds + H_2O→ CH_4+CO_2+$C_5H_7NO_2$+NH_4+HCO_3 **[18]**.

Methane decomposition of biomass is caused by three types of bacteria. In the food chain, subsequent bacteria feed on the products of the previous ones. The first type is hydrolysis bacteria, the second is acid-forming bacteria, and the third is methane-forming bacteria. Not only are the bacteria of the methanogenic class involved in biogas production, but all of the three species.

Organic compounds (proteins, carbohydrates, fats) that are found in biomass begin to break down into the simplest organic compounds (amino acids, sugars, fatty acids) under the action of hydrolytic enzymes. This stage is called hydrolysis and proceeds under the influence of acetogenic bacteria. At the second stage, there is hydrolytic oxidation of some of the simplest organic compounds under the influence of heteroacetogenic bacteria, resulting in acetate, carbon dioxide and free hydrogen. The other part of organic compounds with acetate obtained at the 2nd stage forms C1 compounds (the simplest organic acids). The obtained substances are a nutrient medium for meta-forming bacteria of the 3rd stage. Stage 3 runs on two processes caused by different groups of bacteria. These two groups of bacteria convert the nutrient compounds of the 2nd stage into methane CH_4, water H_2O and carbon dioxide.

Factors affecting the fermentation process:

- Temperature; - Ambient humidity; - PH level; - C : N : P ratio;	- Raw material particle surface area; - Substrate feed frequency; - Retarding substances; - Stimulating additives.

Methane bacteria show their vital activity within the temperature range of 0-70ºC. If the temperature is higher, they start dying, except for a few strains that can live at temperatures up to 90º C. At minus temperatures, they survive, but stop their life activity.

While performing the first experiment at the poultry farm, there has been used a hand-made reactor using a thick plastic bottle, gas pipes and pipes for liquid fertilizer outlet (Figure 1). The installation was carried out in accordance with methane fermentation conditions, with sealants to prevent oxygen from entering the container. Heating to 35-38° C and periodic mixing has been required to maintain bacteria life. The generated biogas has been accumulated in a rubber balloon (at the production site - it must be a special storage, gasholder). To apply the derived methane at a plant, the gas undergoes a cleaning system and is supplied to consumers (boiler or electric generator). The reactor operates without air access and it is airtight and not dangerous. Water contained in biomass does not give gas. It has taken 25 days to obtain a biofertilizer, and the gas has emerged on the 3rd day of the test. Organic fertilizer has been obtained in two forms: liquid and solid. The liquid fraction was light brown, while the solid fraction was dark brown. The solid fraction has become crumbled after release from the container. To speed up the process, one could add yeast fermented in water with sugar or thermophilic enzymes (which are extracted in the laboratory). Many European countries add superphosphates and other ready-made enzymes.

Figure 1: Handmade mini-reactor

The fermentation process of the second experiment has been performed in a thick plastic container, where the dung has been thrown and diluted with 1:1 water. The fermentation mass has started on the second day, on the 15th day the fraction has separated, the solid fraction has been at the bottom of the container. The fertilizer of this experiment has become dark grey, more liquid and contained a distinct pungent smell. The biofertilizer has appeared to be overmoistened, lumpy and left a feeling of scum. The fermentation process has taken 15 days in general.

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On a large scale, the most common industrial method is anaerobic digestion in digesters, where the temperature is regulated, the temperature is fed at different stages and the mass is mixed from time to time.

Application of obtained biofertilizer on Jondor strawberry seeds

The recycled organic waste from the poultry farm has turned into a biomass, which contains a significant amount of nutrients. The main advantage of biofertilizer obtained by anaerobic digestion is the preservation of almost all nitrogen and other nutrients, also a significant proportion of helminth eggs, pathogens and weed seeds are lost in biogas plants.

Two types of pots with meadow soil have been used for further testing of fertiliser efficiency: one of the pots has been fed by the fertilizer from the first trial and the other by the second fertilizer (Figure 2, Figure 3).

Figure 2: Soil for the 1st trial

Figure 3: Soil for the 2nd trial

Stages of organic fertiliser application

1) The soil in pots has been watered. Before top dressing, liquid fertilisers have been diluted at a ratio of 1:20, as the concentration of nitrogen and other substances in it is very high, which may damage the soil and plants. This fertiliser has been used for soil impregnation and periodic watering after strawberry seeds germination.

2) A month before seed settling, the solid crumbled fraction has been used on the pot number 1 from the first experiment (Figure 4). The more liquefied fertilizer has been applied on the pot number 2 (Figure 5).

Figure 4: Solid fertilizer from the 1st trial

Figure 5: Solid fertilizer from the 2nd trial

3) A month later Joydori strawberry seeds are planted and water is poured (Figure 6).

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Figure 6: Joydori strawberry seeds

4) A week later strawberry sprouts have started to appear in the first pot, and 10 days later in the second pot. Seed growth of 12 days has been captured on photos (Figure 7, Figure 8).

Figure 7: Sprouting in 12 days

Figure 8: Sprouting in 12 days

5) Only the soil on the 25th day after the sprouting of Joydori strawberry seedlings has been watered using a liquid fertilizer without touching the plants.

Application of the biofertilizers has resulted in quick humification of plant residues in the soil, helped reduce erosion by forming stable humus and also has increased nutrient content, improved amortization and regeneration qualities of soils. It has been noticed that the activity of earthworms has been increased while applying the biofertilizers.

FINDINGS

The analysis and research carried out at the poultry farm have shown that the trial number 1 using a home-made unit for anaerobic fermentation has taken more time to process manure and additional substrates as opposed to the second. However, the obtained fertilizer from the home-made reactor has a crumbly structure, a homogenous dark brown color and no pungent smell. The fertilizer of the second trial has been less effective: it has been overmoistened, sticking together in lumps, scum and has had an unpleasant smell.

In practice, biofertilizer application has revealed that the fertilizer produced by the bioreactor has proven to be more productive; germination of strawberry seeds started faster and contained more sprouts than in the second pot.

It is important to note that temperature control in the experiments has been the most critical factor in the fermentation stages of bacteria.

The study has found that the digestion process of bird droppings produces not only valuable, highly concentrated organic fertilizer without nitrites, weed seeds, pathogenic microflora, but also biogas. Such fertilizers enhance soil fertility, provide plants with easily accessible nutrients and reduce mineral fertilizer consumption.

CONCLUSION

Uzbekistan has sufficient natural, labor and investment resources for the agricultural development. Establishment of biotechnological processing industry of agricultural wastes solves a number of principal problems influencing each other. First of

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all, ecological problems related to the reduction of ecological harm caused by animal, poultry and plant production wastes. Secondly, it is economic, which makes it possible to produce high-quality organic fertilizers that increase soil fertility and yields. Thirdly, it can be energy-efficient, aimed at creating less expensive energy resources. Finally, it is a very important social component, which helps create new jobs when new production facilities are put into operation.

The processed organic waste can be converted to fertilizers in agriculture. This will reduce the use of chemical fertilizers and reduce the impact on ground water. Biogas production makes it possible to prevent methane emissions into the atmosphere. Methane affects the greenhouse effect 21 times more than CO2 and has been in the atmosphere for 12 years **[19]**. Methane capture is the best short-term way to prevent global warming. Biotechnology based on the use of biogas production waste as a highly efficient, environmentally friendly organic fertilizer is one of the promising solutions for bird droppings recycling. Application of organic fertilizers on alkaline soils leads to neutralization of soil and increase of its humidity, which is especially important for arid regions of Uzbekistan. It is necessary to raise the farmers' awareness of bioreactor efficiency.

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