Technical means for disinfection and processing of bedding manure into organic fertilizers

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Abstract. Organic waste from agricultural production, bedding manure of cattle, pigs, sheep, horses, chickens and poultry litter when kept in cages are the main components for the production of organic fertilizers and biogas production. Waste of grain, cereal crops and sugar beets should be used as components for reducing moisture during aeration in piles, houses and bioreactors. Fresh organic waste should be stored on the sites in piles, where, before being processed in aeration houses and bioreactors, they must go through a mesophilic period. Fresh organic waste, when introduced into the soil in the first year, negatively affects the growth and development of plants, therefore, it must be disinfected and processed into organic fertilizers and biogas. Currently, the lack of knowledge about the methods of disinfection and processing of agricultural waste requires the development of new technological and technical solutions.

1. Introduction
The main source of increasing soil fertility, improving the structure, reducing the density and accumulation of humus in the soil is organic fertilizers. To prepare organic fertilizers, it is necessary to process bedding manure of cattle, sheep, pigs, bedding in breeding poultry farms, semi-liquid and liquid manure, manure when keeping chickens in cages, pot, sapropel, straw of grain and cereal crops, sugar beet tops, fruit and vegetable waste [1-5].

The output of bedding manure from cattle farms with a livestock of 400 cows is 16 tons per day, and poultry litter in poultry farms when keeping in cages 400 thousand chickens is 100 tons per day. This is a huge energy potential. All agricultural waste must be stored on sites in piles, where they must go through a mesophilic period and then be processed in aeration shops, bioreactors, piles and pellet presses. Organic waste contains fungal colonies, helminthes, pathogenic bacteria and weed seeds [4]. Therefore, when preparing organic fertilizers, it is necessary to disinfect organic waste with ultrasonic, ultraviolet radiation, as well as electric fields [4, 5, 8].

2. Materials and methods
The aeration house for agricultural waste is shown in Figure 1. The aeration house consists of building 1 with the dimensions 6×12×4 meters. Air ducts 2 are concreted on the floor with air duct openings 7 5 mm in size. When putting them from the fan 3 at a distance of one meter, the area of the openings is increased sixfold so that the supplied air from the fans is evenly distributed throughout the organic mass. To enrich the air with oxygen, heating elements 4 and ozonizers 5 are installed. Air ducts with a diameter of 100 mm are installed at a distance of 0.5 meters. The organic mass, which has gone...
through the mesophilic process, is loaded into the aeration house. The moisture content of the organic mass should be 50-60%, the bulk density is 0.6-0.7 t / m$^3$, the fractional composition is 1-3 mm, the height of the aerated mass is 2 meters. The production capacity of the house for one cycle is 140 tons (utility model patent No. 2367636) [9].

![Figure 1. Organic waste aerator.](image1)

The aerator-disinfectant of manure and other agricultural waste is a collapsible box 6, on the floor there are air ducts 3 with holes for supplying air to the organic mass 5 by fans 1, equipped with an ozonizer and a heated element 2, and electrodes 7 for creating an electric field in the aerated mass and grill 4 (utility model patent No. 191652) [10].

![Figure 2. Aerator-disinfectant of chicken manure.](image2)

The organic mass is loaded into the aerator-disinfectant with a moisture content of 55 ... 60%, a particle length of 1 ... 3 mm. The density of 0.6-0.7 t / m$^3$ is created due to the spilling of organic matter through the grid 4. After supplying air and creating an electric field, a high-quality environmentally friendly organic fertilizer is obtained within 5 days.

The original design of the aeration bioreactor-disinfectant of bedding manure, chicken droppings and other agricultural waste for the in-line method of preparation of organic fertilizers is shown in
Figure 3 (utility model patent No. 186053) [11]. It consists of a heat-insulating body 1, a loading scraper conveyor 2, a device for leveling organic matter 4, which is installed in the upper part of the body, an unloading conveyor 6, air ducts 10, electrodes for creating an electric field in the organic matter 11.

Figure 3. Aeration bioreactor-disinfectant of bedding manure

The crushed manure is loaded into the aerator with a humidity of 50 ... 60%, then air is supplied through the air ducts. In the organic mass, a thermophilic process takes place within 5 days, after which the finished organic fertilizer is unloaded for ripening. In the process of aeration, the compostable material slowly moves from top to bottom due to gravitational forces and passes through the electric field created by the electrodes and is disinfected from fungal colonies, microbiota, pathogenic bacteria and helminthes.

The operation of the biofermenter is programmed by the MPR-1 device to trigger the MP starter and the P1 and P2 relays in the automatic mode, turns on and off the air supply to the organic mass (Figure 4).

After loading the biofermenter with bedding manure or droppings on the second day, as it can be seen in the graph in Figure 5, when air is supplied by the fans through the air ducts, the temperature of the bioprocess rises to 60 ... 65°C, that is, the thermophilic process takes place for 4 ... 5 days. Then the temperature of the organic mass decreases to 40°C and the organic matter is unloaded onto the site, where it matures for two weeks [7, 12].
Figure 4. Scheme for automatic regulation of the biofermentation temperature: МП – magnetic starter; Р1, Р2 - relay.

Figure 5. Dependence of biofermentation temperature on time. А – heating-up area (mesophilic), Б – burning area (thermophilic), С – attenuation area

The thermophilic process lasts for 4-5 days, and then the attenuation process is observed. The organic mass is unloaded for ripening within 10 ... 12 days. Chemical analysis for NPK was carried out in the center of biochemical technologies REVITAPLANT in Lipetsk, table 1.

Samples were taken from the obtained organic fertilizer to study the presence of fungal colonies,
microbiota, and chemical analysis. Studies of fungal colonies and microbiota were carried out using a Leica DM 2500 microscope in the biotechnology laboratory of Michurinsk State Agrarian University, Figure 6.

### Table 1. Results of chemical analysis of chicken manure

| Sample | Test code   | Micronutrient content, % | Mass fraction of NPK milligram per 100 g of organic fertilizer |
|--------|-------------|--------------------------|-------------------------------------------------------------|
| 1      | I-14-1/19   | 2.56, 3.86, 2.52         | 2560, 3860, 2520                                            |

Figure 6. Fungal colonies and microbiota research facility. 1 - microscope Leica DM 2500; 2 – manure sample; 3 - computer.

### 3. Research of bacterial microbiota in organic fertilizer

The results of studies on bacterial microbiota in organic fertilizer are presented in a graphical form in Figure 7.

From the graph shown in Figure 7 it can be seen that the bacterial microbiota after biofermentation decreases 2.5 times from 4452 cm³ at a temperature of + 65°C.

The graph in Figure 8 shows the results of studies on fungal colonies in the obtained organic fertilizer made from chicken manure through biofermentation when keeping chickens in cages.

The studies have shown that the obtained organic fertilizer kept the Mucor fungus, which was reduced by half and is in the range of 12.6 cm³ to 6.5 cm³. The Penicillium fungus decreased five times, to 0.34 cm³ in the organic fertilizer, at a temperature of 65°C. No other types of fungi were found in the organic fertilizer [8, 13].
Figure 7. Dependence of the volume of bacterial microbiota on the biofermentation temperature

Figure 8. Dependence of fungal microbiota on the temperature of chicken droppings biofermentation

4. Conclusion
The studied designs of aerators and bioreactors are capable of processing agricultural waste into high-quality organic fertilizer. Agrotechnical requirements for waste are the following: moisture content of waste should be 55 ... 60%, density 0.6 ... 0.7 t / m³, fractional composition of particles 5 ... 10 mm. The biofermentation process lasts for 3 ... 5 days.

The chemical analysis of the obtained organic fertilizer showed the following content of elements: nitrogen 2.56%, phosphorus 3.86% and potassium 2.52%. The bacterial microbiota decreased 2.5 times from 4452 cm³ of fresh droppings and 1717 cm³ after the biofermentation, the Mucor fungus was reduced by half and the Penicillium fungus decreased threefold from 1.25 cm³ to 0.34 cm³ after the biofermentation.

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