Processing technology and electrical decontamination of bedding manure and litter in ground trenches and bioreactors

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Abstract. The paper presents data on the effect of electric current on the quantitative index of Mucor and Bacillus fungal colonies in bedding litter. It was found that with an increase in direct current to 3A, the quantitative index (%) of Mucor fungal colonies sharply decreases from 45 to 3 (by 42%), and the quantitative index (%) of Bacillus fungal colonies decreases from 70 to 50 (by 20%). Fresh litter has high acidity, and it cannot be used without preliminary processing and electrical decontamination in ground trenches and bioreactors.

1. Introduction
The important task of agricultural production is the decontamination, disposal and recycling of waste into organic fertilizer, which should be environmentally friendly. Organic fertilizers increase the yield and quality of products, reduce soil density and partially neutralize herbicides and pesticides. Agricultural waste must be stored on sites or in specialized storage facilities. There should be two storage facilities: one is constantly filled with organic waste, and from the second the waste is shipped for decontamination and processing into organic fertilizers [1-3].

The bulk of waste includes bedding manure of cattle, sheep and pigs, poultry manure when the birds are kept in cages and on deep litter, cereal and grain straw, waste from the production and processing of sugar beets, fodder, vegetable and fruit crops, sapropel and peat [1, 4].

The storage of waste there leads to the mesophilic process at natural aeration during 6-8 months. During this period, the organic mass loses a large number of chemical elements: nitrogen, phosphorus and potassium. Chemical elements are washed out by rain and snow waters, and biogas is abundantly released into the atmosphere and pollutes the environment.

As a result, during the natural aeration of waste, pollution of reservoirs, soils and the atmosphere is observed. The temperature during the mesophilic process in the organic mass maximum rises to 40...45°C. At this temperature, microbiota, fungal colonies, bacteria, helmints and weed seeds are preserved in the organic mass. Therefore, when producing organic fertilizers (environmentally friendly), waste must go through the process of decontamination and artificial aeration [2, 3, 5, 6].

Currently, there are technologies for processing and decontamination of bedding manure and litter in bioreactors and aeration workshops. In construction, such technologies require significant capital expenditures. Therefore, we propose a low-cost technology for processing and decontamination of bedding manure and litter in open dismountable ground trenches, which shields are 2.5 meters wide, 2 meters high and may be of arbitrary length. A trench of 30 meters is required per one processing cycle of 135 tons of bedding manure and litter into organic fertilizer [7, 8].
2. Materials and methods

Before laying bedding manure and litter for aeration in a trench, the organic mass shall satisfy agricultural requirements in terms of humidity – 50...60%, density – 0.6...0.7 t/m³ and particle size distribution – 5...10 mm. To grind the organic waste we suggest a caster-grinder of bedding manure and litter (utility patent No. 147043) (Figure 1) [9].

This device has a trailer with a body where a chain-type slatted conveyor is located, a trailer side that limits the waste fall, cross bars and a shaft with knives for grinding. Bedding manure and litter are placed in the body, cereal straw is added to reduce moisture. The chain-type slatted conveyor transfers the organic mass onto cross bars and the knives ground and mix the components into a homogeneous mixture.

The performance of the developed device depends on the conveyor speed. It is expressed by the following formula:

\[ Q = 3.6FpV, \text{ kg/h}, \]

where \( F \) – cross-sectional area of the load in transport, m²; \( p \) – density of manure, litter t/m³; \( V \) – conveyor speed, m/s. The cross-sectional area of the load on the chain-type slatted conveyor is as follows:

\[ F = ab, \]

where \( a \) – load width, m; \( b \) – load height, m.

Figure 1. Caster-grinder of bedding manure, litter and other wastes: 1 – chain-type slatted conveyor; 2 – cross bars; 3 – grinding knives; 4 – shaft; 5 – body; 6 – organic mass; 7 – ground organic mass; 8 – running wheels; 9 – side.

Figure 2 presents a diagram of dependence of the chain-type slatted conveyor performance on speed. The diagram on Figure 2 shows that as the speed of the chain-type slatted conveyor increases, the performance of the grinder decreases, since the grinder does not have time to crush the product.

After grinding and mixing, the organic mass is loaded by free pouring using a manure dispenser MTO-3 into a ground trench with a density of 0.6...0.7 t/m³.

Within three days, the mesophilic process proceeds in the organic mass and the temperature in the mass reaches 40...45°C. Then, the electrodes of the aerator-decontaminator are injected into the organic mass (useful patent No. 179548) (Figure 3). The organic mass is saturated with air, and the electric field created by the electrodes disinfects the mass from fungal colonies, microbiota and helmints [10].

The bioprocess is intensified in the organic mass after oxygen saturation, and the temperature rises to 65°C within five days, and then the temperature decreases, and the mass is discharged from the trench for maturation.
Figure 2. Diagram of dependence of the chain-type slatted conveyor performance on speed.

Figure 3. Aerator-decontaminator of bedding manure, and litter in the ground trench: 1 – tractor; 2 – compressor; 3 – air duct; 4 – arm; 5 – frame; 6 – electrode tubes for aeration; 7 – collar; 8 – insulator, 9 – power supply.

Processing and electric decontamination of bedding manure and litter into organic fertilizer is proposed in the following design of an aerator-electric decontamination agent, presented in Figure 4 (Patent No. 186053) [11].

The proposed design for organic fertilizer processing includes the following: body 1, loading conveyor 2, energy equalizer 3, chain-type slatted conveyor to unload the ready fertilizer 5, loading slatted conveyor for ready-made product 6, dump pit 7, chain 8, scraper 9, aeration pipes 10, electrodes 11, power supply 12, conveyor electric drive 13, blowers 14, thermocouples 15, microprocessor temperature regulator (MPR-1) 16.

Ground bedding manure with moisture content of 50-55% was kept in collars during 3...5 days, then loaded by a conveyor 2 into the body 1, and the uniformity of material distribution throughout the volume was ensured by blades 3 installed on the shaft 15 in the upper part of the body.

Due to gravitational forces, the ground substance slowly moves from top to bottom, and simultaneously through aeration pipes 10, the material is saturated with air, thereby creating favorable
conditions for the development of mesophilic and thermophilic microflora, which, in turn, leads to an intense decomposition of the organic mass, and the temperature rises to 60...65°C, and the electrodes create an electric field in the organic mass and start killing fungal colonies and pathogenic bacteria. Thus, high-quality and environmentally friendly organic fertilizer is obtained.

Figure 4. Aerating bioreactor-decontaminator of bedding manure and litter: I – attenuation zone; II – thermophilic zone; III – mesophilic zone.

3. Experimental procedure
The process of decontamination of litter from fungal colonies was studied on the experimental setup (Figure 5).

Figure 5. Experimental setup for decontamination of litter in DC electric field: 1 – electrode, 2 – chicken litter, 3 – electric field parameter control device (PZ-41), 4 – direct current source (AV971122).
Figure 6. Effect of electrode electric current on the quantitative index of Mucor and Bacillus fungal colonies.

Chicken litter was placed on a site. A positive electrode was then inserted, a negative electrode was attached to the counter, and current was applied to the electrodes for 10 minutes. After completion of the test, 5 samples were taken and the content of fungal colonies was examined on a microscope [12].

The experiments were carried out with five repetitions, and based on the results the experimental dependencies shown in Figure 6 were built.

Thus, Mucor fungal colonies from the mold genus appearing on food products, soil, and organics in violation of their storage conditions may harm human and animal health. When they enter the body, they affect the internal organs thus provoking the death of the body. Bacillus fungal colonies come from soil bacteria that cause toxicoinfection in humans and animals.
4. Conclusion

The studies show that with the increase of direct current to 3A, the quantitative index (%) of Mucor fungal colonies drops sharply from 45 to 3 (by 42%), and the quantitative index (%) of Bacillus fungal colonies decreases from 70 to 50 (by 20%), which increases the ecological purity of bedding manure and litter.

References

[1] Giri R K, Reddy K R 2014 Slope stability of bioreactor landfills during leachate injection: Effects of heterogeneous and anisotropic municipal solid waste conditions Waste Management and Research 32(3) 186-197

[2] Verzilin A, Fedulova Y, Pimkin M 2020 New biologically pure fertilizers in grape nursery E3S Web of Conferences 210 05003

[3] Krivolapov I, Shcherbakov S, Manaenkov K, Korotkov A, Aksyonovsky A 2019 Efficiency of using biological filtering material for environmental support of accelerated waste processing IOP Conference Series: Earth and Environmental Science 403(1) 012136

[4] Krivolapov I, Astapov A, Akishin D, Korotkov A, Shcherbakov S 2019 Determination of the air purification efficiency when using a biofilter Journal of Ecological Engineering 20(11) 232-239

[5] Guryanova J V, Khmyrov V D, Guryanov D V, Khatuntsev P Yu, Aliev T H-H 2020 Effect of different dosages of organic substrate on the catalase activity and the anthocyanins content in the one-year-old shoots of apple tree BIO Web of Conferences 23 01008

[6] Shchegolkov A V, Trufanov B S, Hmyrov V D, Kudenko V B, Guryanov D V, Guryanova Y V 2017 Theoretical Aspects of Construction of Turning up and Loading Machine with Disinfection Option for Agricultural Waste by Carbon Nanostructures Modified Sodium Acetate Nano Hybrids and Composites 13 130-134

[7] Annagulyev G P, Guryanov D V, Khmyrov V D 2018 Device for grinding bedding manure Engineering support of innovative technologies in the agro-industrial complex: materials of the International Scientific and Practical Conference on October 24-26, 2018: collection of scientific papers (Michurinsk: Publishing House of Michurinsky SAU) pp 21-26

[8] Guryanov D V, Khmyrov V D, Guryanova Yu V, Khatuntsev P Yu, Aerator-decontaminizer of bedding manure in storing bunkers, Utility patent No. 179548 Russian Federation, C05F 3/06. Applicant and patent holder Michurinsky State Agrarian University, Application No. 2017106397; applied on 27 February 2017; published on 17 May 2018

[9] Byshov N V, Borychev S N, Uspensky I A, Guryanov D V, Khmyrov V D, Aeration bioreactor-decontaminator of bedding manure, Utility patent No. 186053 Russian Federation, C05F 3/06. Applicant and patent holder Ryazan State Agricultural Technological University named after P.A. Kostychev, Application No. 2018117586; applied on 11 May 2018; published on 27 December 2018

[10] Guryanov D V, Khmyrov V D, Papikhin R V, Maslova M V 2019 Decontamination of chicken litter with ultrasonic radiation Agricultural scientific journal 2 78-81