Using the electrohydraulic impact method to obtain manure fertilizers

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Abstract. Currently, animal husbandry and poultry farming waste, cattle and pig manure, bird droppings are prohibited to be exported to the fields and used as fertilizer without pretreatment. The standard disinfection process is reduced to composting, which takes 3-12 months. A promising direction of intensification of animal waste processing is the creation of a specially formed pulsed high-voltage electric discharge inside the liquid volume. Under the influence of which the microbial flora – bacteria and fungi - intensively dies. Specialists of the SPA "Spiral" have developed a pilot plant for manure treatment. The test results showed that coliform and Enterobacteria, including dysentery bacillus, were completely destroyed after processing a sample of cattle manure by the EGI method.

1. Introduction

Currently, animal husbandry and poultry farming waste, cattle and pig manure, bird droppings are prohibited to be exported to the fields and used as fertilizer without pretreatment.

This is caused by the following reasons:

1. Excess of permissible bacteriological and helminthological indicators.
2. Most of the nutrients are in a non-digestible form for plants.
3. As a result of decomposition of organic substances of fresh manure and chicken manure, methane is released, which is accompanied by an increase in temperature to 60-80°C and burning of plants.
4. The content of weed seeds has been exceeded.

The standard disinfection process is reduced to composting. Animal husbandry waste is stored in special facilities – manure and litter storage facilities, lagoons for storage of liquid manure, at special sites, etc. The minimum reasonable period of preparation (rerotting) is:

- 6 months for cattle manure,
- 3 months for chicken manure,
- 12 months for pig manure.

A promising direction for the intensification of processing animal waste is the creation of a specially formed pulsed high-voltage electric discharge inside the liquid volume, under the influence of which microbial flora – bacteria and fungi - intensively dies. A "biological shield" is being created to guarantee the safety of fertilizers, including thick or drained, solutions or other biologically filled liquids [1-6].

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2. Literature review

For the first time, a new method of converting electricity into mechanical energy as an electrohydraulic effect (EGE) was formulated and designated by the Soviet scientist Lev Alexandrovich Yutkin.

Electrohydraulic effect (EGE) is a method of highly efficient transformation of electrical energy into mechanical energy. When a specially formed pulsed high-voltage electric discharge is created inside the liquid volume (or other substance, including all elastic and even solid materials), an ultra-high hydraulic pressure occurs in the zone of the latter, capable of performing useful mechanical work and accompanied by a complex of physical and chemical phenomena.

The essence of this effect is that when a high-voltage electric discharge passes through a liquid in an open or closed vessel, a certain volume of this liquid located in the interelectrode space instantly boils, resulting in a gas-liquid mixture being formed in the vessel [7, 8].

When processing a substance with an electrohydraulic impact (EGI), complex processes occur (various physical and chemical changes in the processed material) associated with changes in temperature, pressure, occurrence of ultraviolet and sound radiation.

The use of the electrohydraulic impact method is promising in the following directions.
1. Utilization of animal husbandry waste.
2. Production of feed, nutrient mixtures, processing and preservation of products.
3. Maintaining the fertility of the target arable lands, production of fertilizers.
4. Changing the climatic parameters of the area.

Under the influence of EGI, microbial flora, primarily bacterial, is intensively dying. Pathogenic microorganisms are destroyed in the liquid obtained after the EGI [9-15].

3. Research methodology

To implement the EGI method, a source of electrical energy, a processed medium containing weakly conductive liquids, a working chamber or other volumetric localization and technical means to increase the speed of the electrical process are required.

The EGI methodology is reduced to setting up the power plant for the purpose of periodic accumulation and stable pulsed release of stored energy inside the working volume. The purpose of this technique is the efficient conversion of stored energy into mechanical work, precise positioning of alternating zones of high pressure and cavitation, targeted focusing of the impact wave front and its beneficial effects on the objects being processed.

SPA Spiral has created a pilot plant for manure processing by electrohydraulic effect (Figure 1). Figure 2 shows a schematic diagram of an electrohydraulic installation, including a power source with a block of capacitors as electric energy storage devices. The voltage on the capacitors rises to a value at which a spontaneous breakdown of the air forming gap occurs, and all the energy stored in the capacitor instantly enters the working capacity. Where it is released in the form of a short electrical pulse of high power. Then the process is repeated with a frequency depending on the power of the transformer.
4. Results
Microbiological studies of the initial and treated manure were carried out based on the Department of Infectious Diseases and Pathological Anatomy of the FSBEI HE Izhevsk SAA.

The results are shown in Tables 1, 2, 3.
Experiment 1. Material for the study: a sample of manure that has been rotting for 14 days, volume - 1.5 liters. Sample 1 - before processing, sample 2 - after processing. Electrohydraulic impact was carried out with a voltage of 25 kV, the duration of exposure was 13 seconds, the number of discharges was 20.

Results of microbiological research.
Sample 1 (before processing). The total microbial number (TMN) is 960 CFU/g. 3 types of colonies have grown on MPA (meat-peptone agar):
- small, grayish-white, round, convex with smooth edges and a smooth surface (gram-positive rods were detected by microscopy);
- grayish-white colonies, 1-2 mm in diameter, round convex with a smooth surface and smooth edges (gram-positive rods were detected by microscopy);
- grayish-white colonies, 1-2 mm in diameter, with an uneven incised edge, flat (microscopy revealed gram-positive rods, spore-forming).

On the Endo medium, the number of microbial units was 560 CFU/g, while colonies of crimson color, small, with a metallic luster, convex, with even caries and a smooth surface (gram-negative rods under microscopy) grew. It is characteristic of the bacteria of the E. coli group.

Sample 2 (after processing). Total microbial number (TMN) is 560 CFU/g 1 type of colonies has grown on MPA (meat-peptone agar):
- grayish-white colonies, 1-2 mm in diameter, with an uneven incised edge, flat (microscopy revealed gram-positive rods, spore-forming).

On the Endo medium, the growth of characteristic colonies for the bacteria of the E. coli group was not detected.

Parasitological research. With the helminthoscopic method of examination (the Fulleborn's method), eggs of the strongylatosis type were found in both samples under study.

Table 1. Compliance of samples with veterinary and sanitary requirements for organic fertilizers (GOST 33830-2016 Organic fertilizers based on animal waste. Technical conditions).

| Indicator                                | Requirements                  | Sample 1 (before processing) | Sample 2 (after processing) |
|------------------------------------------|-------------------------------|------------------------------|------------------------------|
| Number of microorganisms, CFU/g          | Not allowed                  | 960                          | 560                          |
| Index of sanitary-indicative microorganisms, CFU/g | 1-9                          | 560                          | no                           |
| Presence of viable eggs and larvae of helminths | Not allowed                  | Eggs of the strongylatosis type | Eggs of the strongylatosis type |

Experiment 2. Material for the study: feces of cattle, volume - 1.5 liters. Sample 1 - before processing, sample 2 - after processing. Electrohydraulic impact was carried out with a voltage of 30 kV, the duration of exposure was 13 seconds, the number of discharges was 20.

Table 2. Compliance of samples with veterinary and sanitary requirements for organic fertilizers (GOST 33830-2016 Organic fertilizers based on animal waste. Technical conditions).

| Indicator                                | Requirements according to GOST 33830-2016 | Sample before processing | Sample after processing |
|------------------------------------------|--------------------------------------------|---------------------------|-------------------------|
| Number of microorganisms, CFU/g          | Not allowed                                | 8.7 × 10^6               | 2.2 × 10^6              |
| Index of sanitary-indicative             |                                            |                           |                          |
microorganisms, CFU/g:
- coliforms 1-9
- enterobacteria 1-9

| Indicator | Requirements | Initial manure | Processed manure |
|-----------|--------------|----------------|------------------|
| Number of microorganisms, CFU/ml | Not allowed | 1525 | 750 |
| Index of sanitary-indicative microorganisms (coliform, enterobacteria), CFU/ml | 1-9 | - | - |
| Presence of pathogenic and causative microorganisms, including Enterobacteria (pathogenic serovars of E. coli, Salmonella, protea), enterococci, staphylococci, clostridium, bacilli, enteroviruses, CFU/g | Not allowed | - pathogenic E. coli serovars (2.4 × 10⁶) | - staphylococci - not detected |
| | | - clostridium (0.8 × 10⁶) | - bacilli (0.7 × 10⁶) |
| | Presence of viable eggs and larvae of helminths, including nematodes (ascaridates, trichocephalians, strongylates, strongylloids), trematodes, cestodes, ex./kg | Not allowed | Eggs of the strongylatosis type | no |
| Intestinal pathogenic protozoan cysts, ex./100 g | Not allowed | Eimeria oocysts | Eimeria oocysts |

Experiment 3. Material for the study: a sample of manure that has been rotting for 1 day, volume 1.5 liters. Sample 1 - before processing, sample 2 - after processing. Electrohydraulic impact was carried out with a voltage of 25 kV, the duration of exposure was 13 seconds, the number of discharges was 20.

**Table 3.** Compliance of samples with veterinary and sanitary requirements for organic fertilizers (GOST 33830-2016 Organic fertilizers based on animal waste. Technical conditions).
The test results showed that after processing of the cattle manure sample by the EGI method, coliform and enterobacteria, including dysentery bacillus, were destroyed, the content of which in the initial sample in 1 gr. was 560 units.

5. Conclusion
A pilot plant has been developed, the power and control system has been redesigned and technically improved, and good technical indicators for processing speed and power have been obtained.

The EGI effect allows to efficiently process a large volume of manure with a high degree of biological contamination and obtain organic fertilizer in a short time that meets the veterinary and sanitary requirements for organic fertilizers (GOST 33830-2016 Organic fertilizers based on animal waste. Technical conditions).

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