Electromagnetic Processing as a Way of Increasing Microbiological Safety of Animal Waste

O M Soboleva[1,a], M M Kolosova[1], L A Filipovich[1], V A Aksenov[2,b]

[1]Kemerovo State Agricultural Institute,
Markovtseva St., 5, Kemerovo, Russia, 650056

[2] EkoMashServis, Avtozavodskaya St., 29, Novokuznetsk, Russia, 654038

E-mail: [a]meer@yandex.ru, [b]va.aksenov@mail.ru

Abstract. The article shows the possibility of using the electromagnetic field of ultrahigh frequency (EMF UHF) for drying and disinfecting of such animal waste as pig manure and poultry droppings. The studied modes included the following options: processing exposure of 60, 90, 120 sec, the capacity of 60 kW, the frequency of 915 MHz. The method of UHF processing of manure and poultry droppings is environmentally safe and effective in neutralizing the pathogenic microflora, as well as larvae and eggs of worms. The following processing mode of animal waste in the electromagnetic field of ultrahigh frequency was recognized as optimal: exposure of 90 seconds, the capacity of 60 kW, the frequency of 915 MHz. This option leads to the complete destruction of pathogenic and conditionally pathogenic microorganisms, as well as the eggs and larvae of worms. As a result of this processing, a high level of microbiological safety of pig manure and poultry droppings is achieved that allows using them as organic fertilizers. The peculiarities of some species of pathogenic fungi developing on the surface of the wheat grain are shown. Pre-processed animal waste (pig manure and and poultry droppings) were applied in experimental variants. Used organic fertilizers underwent electromagnetic processing of ultra-high frequency. The qualitative composition of the microflora on the surface of the grain depends on the type of animal waste (manure or droppings) and used dose. The safest part of the microflora of grain was marked with the application of the UHF-processed pig manure and poultry droppings in doses of 10 t/ha.

1. Introduction

Intensification of livestock production causes a greater unfavourable impact on the environment [1, 2]. Problems of storage, processing, disposal and use of the livestock industry waste of agricultural production are among most urgent nowadays [3-5].

One of the most common ways of their solution is to use livestock manure and poultry droppings as organic fertilizers for restoring and / or improving the fertility of agricultural land. However, this significant biological resource is used by no more than 25-30% because of the lack of efficient and economical technologies of preparation liquid and semi-liquid waste of animals and poultry to be used as organic fertilizer.

In agriculture, livestock waste as fertilizer are used in various forms beginning from fresh manure up to materials that undergone a profound transformation such as biological [6] (eg, after the anaerobic

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digestion for obtaining biogas) [7], the chemical (by formalin, ammonia, ozone, chlorine, etc.) or physical (by ionizing radiation) [8]. One tries most often to add materials that have passed at least the minimal processing, for example, partially decomposed materials in clamps instead of fresh ones [9].

It is proved that the use of organic fertilizers such as pig manure is not inferior in their effectiveness to application of fertilizers [10]. Today, there are a lot of environmentally friendly technologies of manure processing [11], but some of them lead to a significant loss of nutrients [1, 12], others are not sufficiently effective in terms of decontamination [13, 14].

Composition of pig manure is quite diverse and can satisfy not only the needs of crop plants in the main supply elements (nitrogen, phosphorus, potassium), but also in the macro and micronutrients such as iron, magnesium, calcium, zinc [10]. However, at the same time, manure and poultry droppings are objects that potentially hazardous to health of human, animal and plant because they can contain a huge number of microorganisms (including pathogenic), larvae and eggs of helminths, weed seeds. Contamination by pathogenic microorganisms which are in manure or poultry droppings includes the following areas for distribution: direct transfer of pathogens to humans, for example, the staff of the livestock enterprise; the spread of diseases affecting farm animals; water pollution from further migration of environmental chains; contamination of foodstuffs [15, 16].

Therefore, the use of manure and droppings as fertilizers should be accompanied by a number of measures to ensure their complete disinfection and desinvasion [17, 18].

If livestock intensification continues (and that is what we have seen), there is the need to develop technologies and control strategies of environmental problems associated with this issue.

The method of UHF processing of native manure and droppings can become such method that can solve simultaneously some aforesaid problems such as effective disinfection, preservation of value of waste as fertilizer, reducing processing times.

2. Materials and methods

The industrial installation «Volna-100K» (Ltd. «EkoMashServis», Russia) was used for UHF processing of native pig manure and poultry droppings. The investigated processing modes are presented in Table 1. They differed only by the exposure time. These modes were selected in advance, based on the technical possibilities of installation, compliance with energy efficiency conditions, as well as the need to bring the initial raw materials to the required level of humidity (30-50%).

Table 1 – Options of investigated processing modes of pig manure and poultry droppings

The processing option	Magnetron power, kW	Magnetron frequency, MHz	Processing exposure, sec
Initial pig manure (0)	0	0	0
UHF-processed pig manure (1)	60	915	60
UHF-processed pig manure (2)	60	915	90
UHF-processed pig manure (3)	60	915	120
Initial poultry droppings (0)	0	0	0
UHF-processed poultry droppings (1)	60	915	60
UHF-processed poultry droppings (2)	60	915	90
UHF-processed poultry droppings (3)	60	915	120

UHF-processed pig manure poultry droppings organoleptically represent a flowing bulk and particulate material of brown color with inclusions (particles of food), low odor of the initial raw material, moisture content of 43.6% and 33.0%, respectively.

Research of microbiological and parasitic safety of UHF-processed organic fertilizers was carried out in the Test center of Kemerovo Interregional Veterinary Laboratory (Kemerovo).

After the UHF processing the manure and droppings were added into the soil in predetermined amounts with further hand application.

Field experience included the following options of application into the soil before planting:

1. Control without application;
2. UHF-processed poultry droppings, application rate of 5.0 t / ha;
3. UHF-processed poultry droppings, application rate of 10.0 t / ha;
4. UHF-processed poultry droppings, application rate of 15.0 t / ha;
5. UHF-processed pig manure, application rate of 5.0 t / ha;
6. UHF-processed pig manure, application rate of 10.0 t / ha;
7. UHF-processed pig manure, application rate of 15.0 t / ha;

Location of plots was consistent. Repeatedness was triple. The plot area was 1 m^2. The object of the study was spring wheat of variety Novosibirskaya 31. The sowing of wheat seeds was conducted on the 10th of May in 2016. The seeding rate was of 6 million germinating seeds per hectare.

Soil was presented by podzolized humus. Humus content was 8.6%. Phosphorus content was increased (approximately 150 mg / kg). Potassium content was high (170 mg / kg), nitrate nitrogen content was average (approximately 6 mg / kg) and pH_{sol} was 5, 9.

Two months after the harvest (15.09.2016) the mycological study of spermosphere of received wheat grain was conducted. For this purpose the sowing of swabs from the surface of the seeds on a nutrient medium Saburo was carried out. The cultivation was carried out at a temperature of 30 ° C for 48 hours (preliminary registration of the results), followed by rearing and definition of micromycete. Systematic fungus belonging up to the genus was determined.

3. Results and their discussion

Danger level of studied native pig manure in the microbiological and parasitological respect is relatively low and is represented in four taxa, indicating a relatively high sanitary level that is maintained on livestock enterprise. The qualitative composition of conditionally pathogenic and pathogenic microflora, as well as larvae and eggs of helminths in the native sample of pig manure is not too diverse and represented, respectively, by two types of microorganisms and two kinds of worms. Among the identified microorganisms one of the species (*Citrobacter diversus*) refers to the coliform bacteria, representatives of the intestinal microflora of humans and animals. It is characterized as conditionally pathogenic species capable of causing a wide range of diseases both in humans [17] and farm animals and poultry [19]. There is evidence that bacteria of this type are much more susceptible to disinfection than intestinal protozoa and viruses [20]. The second type (*Staphylococcus hyicus*) is the causative agent of zoonotic diseases, some strains of which can cause exudative parakeratosis of pigs [21].

The data obtained indicate a strong influence of the electromagnetic field of the UHF on the microflora and juvenile stages of parasitic flora of the studied animal waste. Some selected modes can lead to a reliable disinfection of these types of raw materials and complete inactivation of mentioned above species. It is shown that bacterial microflora found in the initial pig manure was more resistant to UHF processing than helminths (Table. 2) which are killed by all studied modes of processing, including minimum exposure, whereas microbial component is stored in its entirety at the option of 60 sec exposure. However, microorganisms found in the native materials die with increasing time of exposure of UHF energy on the studied raw material up to 90 and 120 sec. Thus, disinfection of pig manure on microbiological and parasitological parameters can be achieved at satisfactory extent even at the level of average processing time as 90 sec.

The total number of microorganisms, larvae and helminth eggs identified in investigations of native poultry manure was even less than in manure research and amounted to three taxonomic units. One type of bacterium *Proteus* and one kind of staph *Staphylococcus xylosus* refer to conditionally pathogenic microflora. Also one species of parasitic roundworms of kind *Ascaridia galli* (Table. 3) was found. It is indicated in some papers that some strains of S. xylosus are absolutely harmless and even used in the food industry as starting cultures [22]. Other scientists argue that this species belongs to conditionally pathogenic microorganisms and has multidrug-resistant to various antibiotics [23].

There is evidence that some strains of this species can serve as sources of opportunistic infections of animals [24, 25]. Since it is unknown exactly what kind of staphylococcus was isolated in this case, we will adhere to the maximum harm hypothesis and assume that pathogenic strain was isolated.

Table 2 – Results of microbiological and parasitological studies of pig manure

Type of tested substrate	Microbiological / parasitological index			
	Coliform bacteria of species *Citrobacter diversus*	Pathogenic bacteria of species *Staphylococcus hyicus*	Larvae and eggs of nematodes of the genus *Strongyloides*	Larvae and eggs of nematodes of the suborder *Strongylata*
Initial pig manure (control)	+	+	+	+
UHF-processed pig manure (1)	+	+	–	–
UHF-processed pig manure (2)	–	–	–	–
UHF-processed pig manure (3)	–	–	–	–

Studies on UHF processing of poultry manure showed similar tendencies observed for the experiment with pig manure. Bacterial microflora was more resistant to this type of radiation than helminths and withstood minute exposure at specified power and frequency parameters. However, conditionally pathogenic microorganisms *Proteus mirabilis* found in the initial raw material were less stable than staph and died already at 60-second duration. Two modes of decontamination of droppings were recognized as effective in which the entire pathogenic and conditionally pathogenic bacterial microflora, as well as larvae and eggs of helminths were completely destroyed. These modes were with exposition of 90 and 120 sec.

Table 3 - Results of microbiological and parasitological studies of poultry manure

Type of tested substrate	Microbiological / parasitological index		
	Conditionally pathogenic bacteria of species *Proteus mirabilis*	Conditionally pathogenic bacteria of species *Staphylococcus xylosus*	Larvae and eggs of kind *Ascaridia galli*
Initial poultry droppings (control)	+	+	+
UHF-processed poultry droppings (1)	–	+	–
UHF-processed poultry droppings (2)	–	–	–
UHF-processed poultry droppings (3)	–	–	–

The obtained data of field trials suggest that the formation of the qualitative composition of microflora of grain of spring wheat is affected by the type and dose of UHF processed animal waste.

Our studies indicate that the predominance of different micromycetes depends on the amount of applied organic fertilizer. Thus, the application of manure and droppings at a dose of 10 t/ha leads to the predominant development of the fungi of the *Rhizopus*. At the same time the growth of remaining fungi is inhibited.

Increase in the dose of applied UHF-processed poultry droppings up to 15 ton per hectare gives rise to the phytopathogen *Fusarium* among others.

In all the studied variants of application, including the control, the presence of such micromycetes as *Helminthosporium* and *Alternaria* recorded was recorded.

It should be noted such particularly of studied grain as the complete absence of the so-called «storage» molds – representatives of *Aspergillus* and *Penicillium*, which probably explains the small grain storage period, during which the phytopathogenic microflora has not had time to be replaced by the storage molds.

4. Conclusion

Two studied modes of UHF processing with medium and long duration of action (90 and 120 sec respectively) lead to the same results in terms of efficiency of disinfection of pig manure and poultry droppings by UHF energy. But it is more rational to use the version with a shorter duration of the processing since in this case the energy saving is achieved and it is possible to process larger quantities of raw materials per time unit.

The qualitative composition of microflora of the surface of the wheat grain is determined by edaphic conditions of the place of growth and also depends on the type and dose of applied UHF-processed animal waste. The safest part of the microflora of grain was marked with the application of the UHF-processed pig manure and poultry droppings in doses of 10 t/ha.

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