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Prospective Technology for Processing of Manure and Dung.

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ABSTRACT

The paper presents the analysis of the modern condition of processing manure of stock-raising companies into organic fertilizers. It was established that nowadays the use of manure in a form of organic fertilizers is ineffective; moreover, so far there are no effective technologies of processing manure and production of high quality organic fertilizers on its basis, which would ensure the increase of soil fertility, as well as the production of lucrative crops. On the basis of the principles of systems approach to the design and application of the technology of the production of manure and dung, stock-raising and crop growing are united into one system, in which manure and dung are considered not as wastes of stock-raising companies, but as a valuable product for manufacturing high quality organic fertilizers. Prospective technologies for processing of liquid, semi-liquid and bedding manure of stock-raising companies into solid and liquid concentrated organic fertilizers by means of the method of accelerated composting in stationary and field conditions were developed. The study deals with the technical facilities for the implementation of the proposed technology. The proposed technologies are implemented in agricultural companies of Rostov Oblast. The study presents technical and economical characteristics of the implementation of modern technologies of processing manure into high quality organic fertilizers and their application in crop-growing, which demonstrate the increase of profitability of the production of agricultural crops due to the crop capacity, which increases faster, than additional expenses for additional technological operations.

Keywords: bedding manure, liquid manure, semi-liquid manure, technology, concentrated organic fertilizer, accelerated composting.

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INTRODUCTION

Nowadays there is a tendency for the increase of livestock and poultry population all over the world. World cattle population is, approximately, 1.3 billion of heads. More than 1 billion of pigs are raised every year. Poultry-raising is also growing rapidly.

At the same time, the increase of cattle and poultry population leads to the increase of the volume of produced manure and dung of various consistencies. Stockpiles of organic wastes of stock-raising and poultry-raising, generally, do not meet sanitation requirements, which leads to the contamination of environment.

Fresh manure and dung contain large amounts of pathogenic micro flora, which is dangerous for flora and fauna. However, they also contain large amounts of nutritive matters, such as nitrogen, phosphorous, potassium and microelements, which contribute to the increase of the fertility of soils and productivity of crops. Therefore, processing of manure and dung into applicable products requires special approach from the points of view of ecology and economic efficiency.

Nowadays, the use of manure in a form of organic fertilizers is ineffective; moreover, so far there is no effective technology of processing manure and production of high quality organic fertilizers on its basis, which would ensure the increase of soil fertility, as well as the production of highly profitable crops.

The major share of world production of fertilizers is mineral fertilizers. Organic fertilizers nowadays occupy about 2% of world production volume (0.8 mlntons of weight of active matters or 12 mlntons of total weight); at that, the shareof that kind of fertilizers grows very rapidly. According to the forecast, by 2018 the volume of organic fertilizers, which is produced using industrial-scale technologies, will increase to 2 mlntons of weight of active matters or 28 mlntons of total weight, and by 2025 it will reach 5-7 mlntons of weight of active matters or 70-100 mlntons of total weight.

In the agricultural companies of the USA, which implement elements of organic agricultural technology, the crop capacity of 60 centner/hectare or more is achieved. In that country there are 1,400 production facilities, which process organic matters into humus. In Germany the state provides subsidies for the development of biological agriculture without pesticides and chemical fertilizers. In Japan biotechnologies are also implemented, and the island state with shortage of acreage is completely self-sufficient in all kinds of food products. In Saudi Arabia biohumus and biotechnologies imported from Europe allowed it to export tens of thousands of tons of wheat and fresh cow milk.

It is important for a producer of organic fertilizers to find its customer and demonstrate the quality of its product. Firstly, organic fertilizers are indispensable for poor soils with low physical and chemical characteristics. In recent years farmers, which manufacture high quality and ecologically safe products, while keeping the fertility of soil at a high level, show the increasing interest in organic fertilizers. Moreover, organic fertilizers are indispensable for the development of plantations of fruits and berries.

Therefore, the solution of that problem is an important scientific and practical problem.

METHODOLOGY

Scientists from Russia and from abroad currently carryout research in the field of the development and implementation of various technologies of processing of manure and dung into organic fertilizers. However, due to a wide variety of technologies of raising of livestock and poultry, their feeding rations and other factors, manure of varied moisture and varied composition of nutrients, contributing to the fertility of soil and capacity of crops, is produced. Therefore, the implementation of the technology of processing of organic wastes must be carried out specifically for each site, with the consideration of physical, mechanical and chemical properties of produced manure and dung, as well as taking into account the content of nutrient matters in the soils of a certain region.

The application of system approach during the development of technology of processing of manure and dung allows to join industries of stock-raising and crop-growing into one system, in which manure and dung are considered not as waste of stock-raising companies, but as a valuable product for production of high

quality fertilizers, which are necessary for effective production of crops, which is the main manufacturer of fodder for poultry and stock [3-4]. Therefore, manure and dung are, on the one hand, the sources of contamination of environment, but from another point of view they are the main components for the production of organic fertilizers, which contain nutrients, required for soil and crops.

There are existing technologies of the production of solid and liquid organic fertilizers in Russia and abroad, which imply spreading of them on soil with doses of 40-60 ton/hectare; the related expenses are, generally, not compensated by the increase of harvest of produced agricultural crops, which leads to the decrease of profitability of production [3].

The most prospective direction, which is under development in many countries, is the production of concentrated organic fertilizers (COF) from manure and dung, which have the shortest time of production, higher concentration of nutrient matters and low spreading doses (up to 10 ton/hectare) [3, 5]. Low spreading doses of COF allow to decrease operating expenses on transportation and spreading of organic fertilizers, which is especially important for crop producing regions of Russia (Rostov Oblast, Krasnodar Krai and Stavropol Krai). In Rostov Oblast, which has the acreage of more than 5.7 mlnha, the average radius of transportation of fertilizers is 5 km [6].

MAIN PART

Researchers of Rostov Oblast (Rostov-on-Don, Zernograd) developed the technologies for the production of COF on the basis of manure and dung with the implementation of biologically active α-additive. The conducted studies and large-scale production trials during 30 years proved the potential of the application of these technologies [7].

Stock-raising and poultry-raising companies produce, depending on the technology of keeping of stock and poultry, liquid (moisture W>92%), semi-liquid (W=86-92%) and solid (W<86%) manure and dung. On the basis of wide swing of moisture of the produced organic wastes, we developed the technologies for production of solid and liquid COF.

The production process has the following main points. Bedding manure (dung) with the moisture $W_{init.}$<86% is transported from manure stockpile to the site to separate it from foreign matters. As the equipment for separation of foreign matters we used the equipment based on spreader of organic fertilizers ROU-6, which feature is horizontal shaft (which replaced spreading augers) placed along wide part of the body with chains, which ends are fit with hammers having sharp edges along their perimeter; chains are connected to the shaft by means of hinges and situated according to the special layout [8]. At that initial manure is loaded into the feeding bunker of the spreader and then moved into the zone of operation of hammers by the bottom transporter. At contact with hammers organic mass is uniformly ground into particles of 3-5 cm and is formed into the pile of 2.5 m width; separated foreign matters are placed separately from manure by means of the bottom transporter.

Prepared organic mass is transported to the storage bunker, from which it is fed to the hammer grinder by means of the belt conveyor. From the grinder the ground mass is transported into two batch-type bio-reactors placed in parallel. At the same time with the ground mass the bio-rectors are fed with liquid biologically active α-additive in volume of 5% from the fed organic mass. Components are thoroughly mixed by means of the blade-type mixers; at the same time the organic mass is rapidly heated to a temperature of 65-70°C, as a result, bio-thermal disinfection of the mass occurs, and it is saturated with centers of soil formation (CSF). It was experimentally proved that the cycle of bio-thermal disinfection takes 45-60 min. Solid COF, which is produced at output of the bio-reactors, is transported to the storage bunker; at that, the moisture of COF W´´ is decreased to 50% and the volume $V_1''+V_2''$ is decreased by 25-35%. After the storage bunker COF is transported to the separation zone and after that to the packaging device, which distributes COF to package from 3 kg to 1 ton. After packaging COF is transported to the warehouse, to customers or to field, where it is spread on soil in doses of 4 tons/hectare.

The modules for the production of solid COF with the capacity of 2,500 ton/year of initial manure (dung) are designed. The cost of the produced COF is 2,650-2,700 rubles/ton. The required electric power for the operation of the production line is up to 250 kW.

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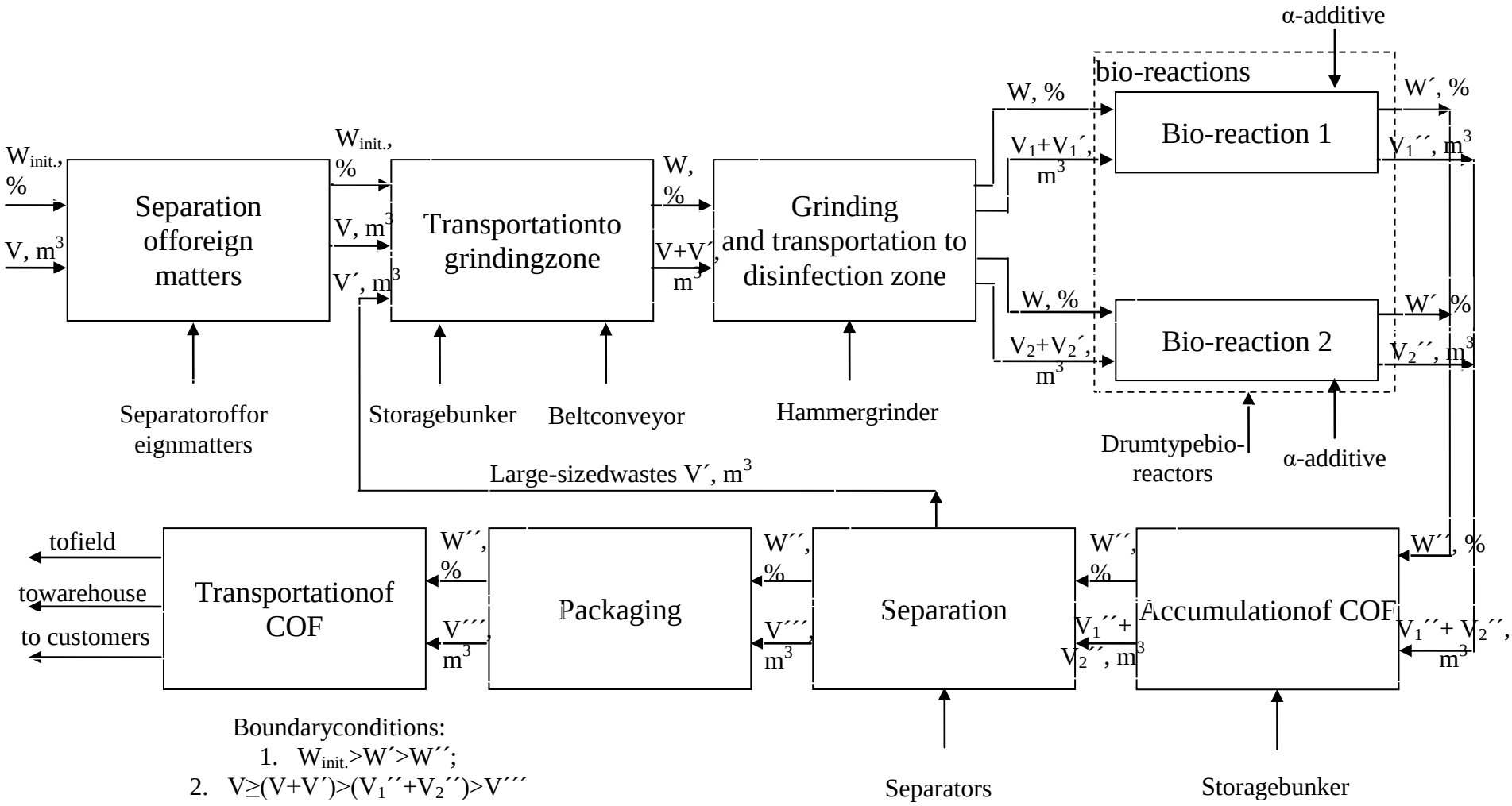

Figure 1 – Flowchart of the technological process of production of solid COF in stationary conditions
$W_{init.}$ – moisture of manure (dung); V – volume of processed manure (dung)

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In recent years in farms of Rostov Region the technology of production of COF using the method of accelerated composting of manure (dung) becomes widely spread. The main point of the method is that manure (dung) is transported from technological spaces or storage spaces to a specially prepared zone, where it is formed in piles. After the addition of α-additive the components are thoroughly mixed, and bio-thermal disinfection with saturation with CSF takes place. After 8-10 days COF is ready for use.

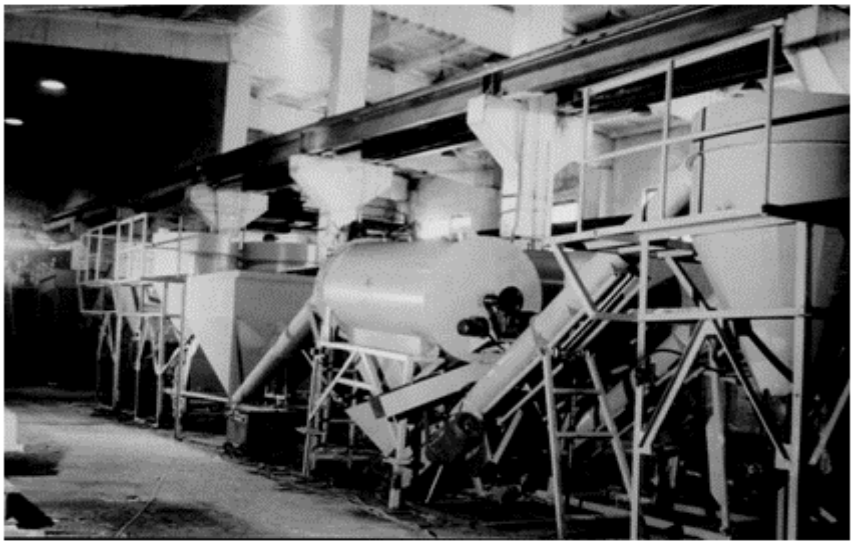

Figure 2 – Overview of fragment of stationary technological line for production of solid COF

The authors developed two technologies of the production of solid COF using the method of accelerated composting: stationary (operational all around the year) and field (operational during warm period).

The production process using that technology has the following main points. At the first stage the separation of foreign matters from manure (dung) with moisture of $W_{init.}$<86% is carried out in a way, similar to that mentioned above (Figure 1). The zone with hard surface and systems of transversal and longitudinal air channels, which is covered with shed, is prepared. Organic mass is transported using the transport wagons to the zone and formed in piles; the piles are situated in the way that longitudinal air channels are situated along their central axes. Width of the piles is 2.5 m and height is 1.5 m. At the same time, α-additive is introduced in the piles with dosages of 15 kg per 1 linear meter of the pile; after that the pile is mixed using mobile pile agitator (MPA). In cold seasons hot air is supplied to the pile, which significantly accelerates the process of heating of organic mass and decreases time for its bio-thermal disinfection.

After 8 cycles of agitation with time interval of 10-12 hours finished solid COF is loaded into dump-trucks by front-end loaders PFP-1.2 (PFP-2.0) and transported to the packaging zone. After packaging COF is transported to the warehouse for storage, delivered to customers or spread on fields with dosages from 1 to 4 tons/hectare. Averages length of production cycle of solid COF by means of the method of acceleration composting in winter season is up to 10 days. The cost of COF produced using the described technology is 2,509 rubles/ton. Overview of the production facility of solid COF manufactured using the method of accelerated composting in stationary conditions is presented in Figure 4.

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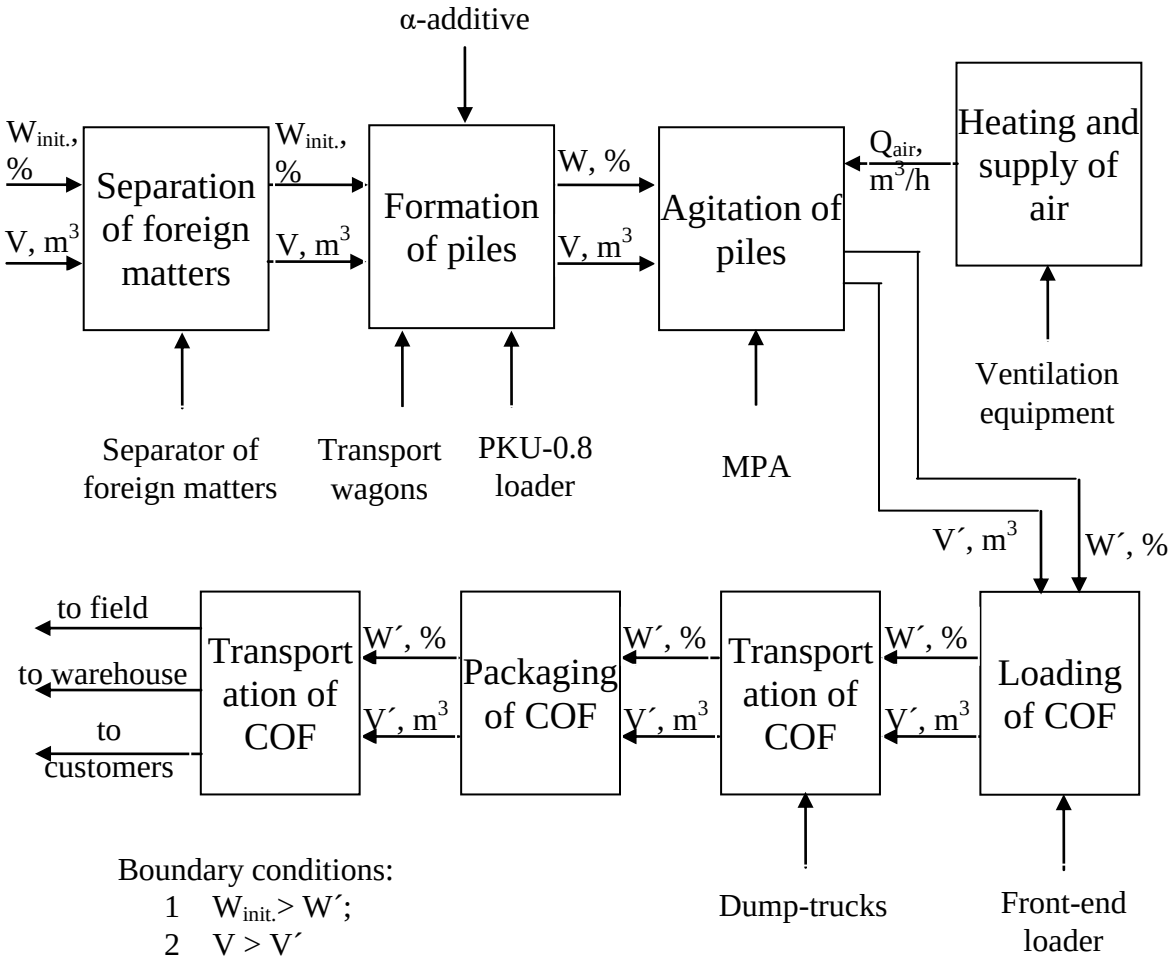

Figure 3 – Flowchart of production process of solid COF by means of the method of accelerated composting in stationary conditions

Figure 4 – Overview of covered zone for production of solid COF by means of method of accelerated composting

Field variant of technology for production of solid COF by means of the method of accelerated composting uses and open leveled space with hard or soil surface and drainage systems (Figure 5).

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The process of the production of COF by means of the method of accelerated composting in field conditions is the most widely spread; it makes it possible to produce high-quality fertilizers in spring and summer seasons in order to spread them on soil prior to main treatment of soil for production of winter crops.

Separation of manure (dung) from foreign matters, formation of piles and introduction of α-additive is carried out in a way, similar to the described above. Agitation of piles by means of MPA allows to rapidly heat the mass (after 2.5-3.5 hours in summer season) and carry out bio-thermal disinfection. It was experimentally established that for the production of solid COF at temperatures of outdoor air of more than 16°C it is enough to carry out 6 cycles of agitation with 10-12 hours interval. Total length of solid COF production cycles at open spaces using the method of accelerated composting is up to 7 days. The cost of the produced COF is 614-845 rubles/ton. Dosage of the introduced solid COF is 1-4 tons/hectare.

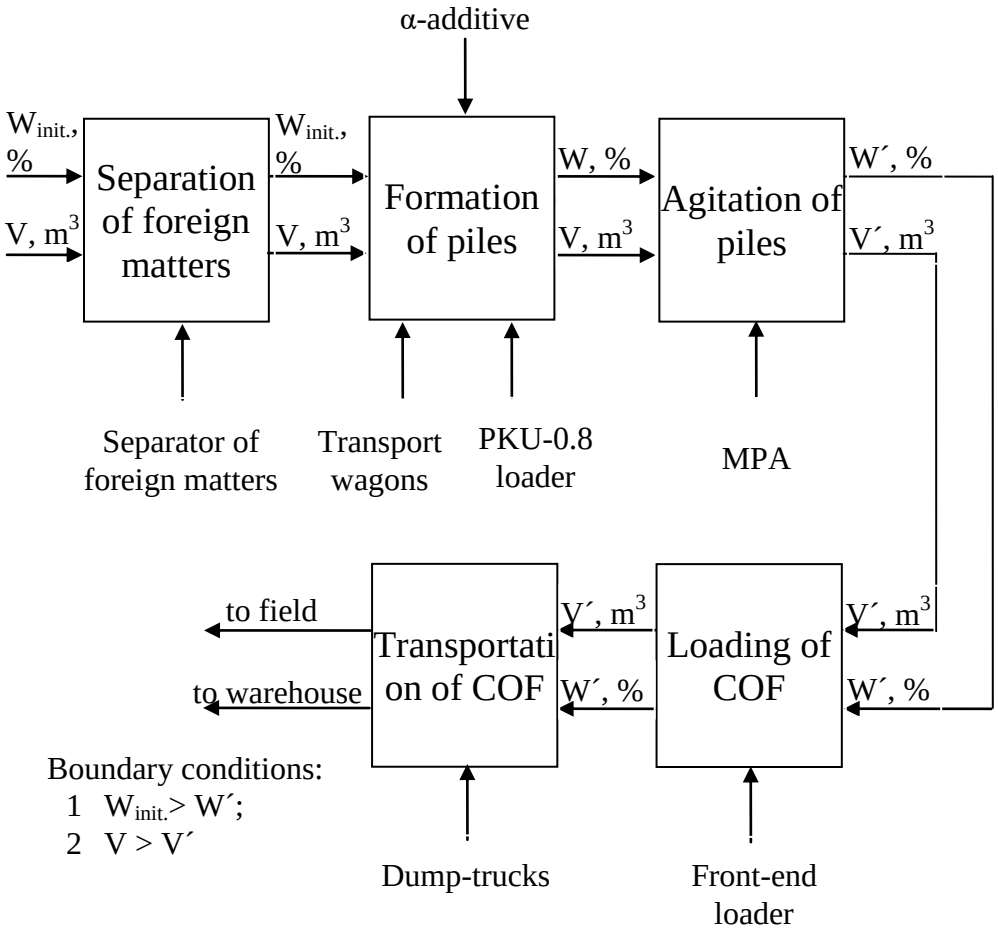

Figure 5 – Flowchart of production process of solid COF by means of the method of accelerated composting in field conditions

If it is required to package the produced COF, packaging equipment can be installed, and the process is carried out in a way, similar to the described above (Figures 1, 3).

The major part of stock-raising and poultry-raising companies produce semi-liquid (W>90%) and liquid (W>92%) manure and dung, which is accumulated in special spaces of various volume. Various technologies for processing of liquid and semi-liquid organic wastes exist. The most widely spread technology is the separation of organic wastes into liquid and solid fractions by means of mechanical separators, which is sometimes unreasonable from the point of view of economy.

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Figure 6 – Overview of COF production space using the accelerated composting technology at an open space

The authors developed the technology for production of liquid COF from liquid and semi-liquid manure and dung (Figure 7).

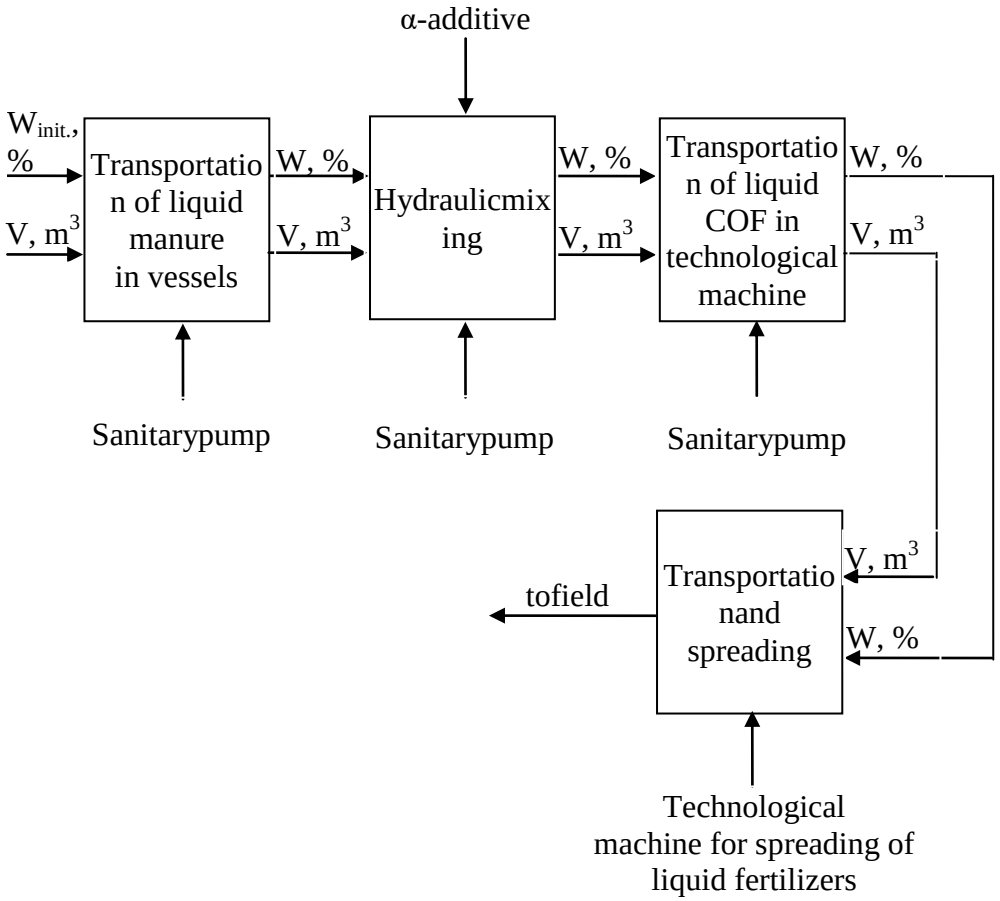

Figure 7 – Flowchart of production process of liquid COF

The production process of liquid COF has the following main points. Sanitary pumps transport liquid manure (dung) through pipelines from storage space into vessels, the number of which depends on the capacity of the production line. Each vessel is equipped with hydraulic mixing systems, unloading systems,

systems for addition of α-additive in liquid and powder form. Each vessel is filled for 2/3 of its volume with liquid fraction;α-additive is introduced in volume of 5% from volume of liquid organic matter; after that hydraulic mixing process starts. It was experimentally proved that time for saturation of liquid with CSF is 50-60 min.; after that liquid COF by means of a centrifugal pump is supplied to the technological machine via pipelines; the technological machine transports and spreads COF on soil in doses of 1 to 4 m^3/hectare. The cost of production of liquid COF is 672 rubles/m^3.

Figure 8 – Overview of the equipment for production of liquid COF

Concluding part. The presented technologies for processing of manure and dung into solid and liquid COF underwent production trials in agricultural companies of stock-raising, crop-growing and mixed companies of Rostov Oblast of the Russian Federation. On the basis of the carried out technical and economic analysis it was established that the production of COF using the described technologies and spreading it on fields with doses up to 4 ton/hectare allow to decrease the amount of used mineral fertilizers in two times and increase the profitability of crop production by 20%, sunflower seeds by 13% and corn (for crops) by 45% [9-12]. Payback time of the implemented technologies is 1.3-1.6 years.

CONCLUSIONS

1. For the processing of manure and dung it is reasonable to use prospective technologies for the production of concentrated organic fertilizers using biologically active α-additive. The production cycle of solid COF is 7-10 days.

2. The application of the technology for the processing of manure and dung into concentrated organic fertilizers using the method of accelerated composting, and their spreading on soil with doses up to 4 tons/hectare allows to increase the profitability of production of intertilled crops by 13-45%. The cost of solid COF is 619-2,700 rubles/ton.

3. Processing liquid manure into liquid COF with the cost of 672 rubles/m^3 makes it possible to successfully use them in crop-growing with the dosage of 1-4 m^3/hectare in case of spreading prior to main treatment of soils.

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