Development trends of a waste processing system as a factor of improving the efficiency of agricultural enterprises

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Abstract. Recently, much attention has been paid in the world community to environmental protection, human health, mainly through the reduction of production and consumption waste dumping. Today, the problem of waste is the most relevant. Waste becomes not only a source of environmental pollution, but also deteriorates the sanitary-epidemiological and aesthetic qualities of nature. Besides, some wastes have properties that allow their further use as secondary raw materials, which is quite interesting from the point of view of their use as a material resource, and their return to the circulation of working capital acquires an important environmental, economic and energy-saving value. The purpose of the study is to characterize modern technologies for processing agricultural waste and to offer directions for waste integrated management. It is planned to collect information presenting a particular practical interest to agricultural producers, as well as to state and other regulatory bodies in the field of agriculture. The methodological basis of the study included the provisions of various theories and methodologies for the analysis of agricultural sustainability, methods to forecast the economic development of rural territories. The information base of the study was statistical collections and directories of state and regional statistics bodies, federal and regional regulatory legal acts, expert databases.

1. Introduction
The problems of the modern times caused by significant population growth, resource extraction, consumption change, deterioration of the quality of fertile soils, and at the same time the increase of produced waste are considered by many scientists as a serious threat requiring immediate action. One of the industries that holds the leading position in the field of produced waste, environmental pollution, which also leads to global warming, is the agro-industrial complex.

Omsk region is considered an agricultural region of Russia. It has sufficient natural, labor and investment resources for agricultural development. The geographical location of the region contributes to the development of agricultural sectors, such as crop production, animal husbandry and poultry farming. However, the development of these sectors also leads to a negative sanitary and environmental impact on the environment. The objects of harm within the complex are as follows: soil (waste often remains in the fields, as well as the surplus of protection means and fertilizers, as a result, land plots become more susceptible to erosion); atmosphere (uncontrolled aerobic and anaerobic processes during biological decomposition of organic substances, including those accumulated in spontaneous landfills, release toxic compounds and greenhouse gases into the environment), water
resources (harmful substances getting into water bodies with groundwater thus contaminating them) [1, 2].

As practice shows, understanding the benefits of modern methods Russian agricultural producers often continue to use outdated methods. This is especially the case for medium and small agricultural enterprises that are not fully aware of available opportunities, do not have a sufficient level of competence in the field of recycling, and therefore do not make significant attempts to change the approach to economic activity. However, having significant revenues due to the volume of sown areas large holdings are in no hurry to introduce innovative technologies in this area, considering these areas not effective from the economic perspective.

Nevertheless, there are already a number of successful examples of solid waste management. In particular, in Lipetsk region a plant working on Czech technology processes 50 tons of waste annually, producing technical fat, feed, and fertilizers. For example, from rice husks it is possible to make amorphous silicon, which is extremely popular on the market, from hemp straw - coatings for welding, from sugar beets - pectin, gelling substances for confectionery. However, there are no such industries in Russia [3].

2. Problem statement

Experts estimate that 470 million tons of waste are generated annually in agriculture. The yield of the main product makes 15-30% of the feedstock weight [4]. The Strategy for the development of the industry for production waste processing, disposal and neutralization and consumption until 2030 adopted in the Russian Federation [5] implies the processing of that up to 80% of waste in 12 years. However, such an optimistic forecast raises concerns, given that the processing rate is currently less than 10%.

Figure 1 shows the distribution of the share of generated wastes by agricultural activity.

![Figure 1. Distribution of the share of generated waste by agricultural activity](image)

The above data confirms that crop production together with animal husbandry form the majority of wastes within the agro-industrial complex [6]. However, the damage from unused plant wastes is more diverse than "traditional" environmental problems. Waste generated in the crop industry often remains in the fields, as well as excess chemical plant protection agents and fertilizers. As a result, land is more vulnerable to erosion. Hence, agriculture loses about 4 million tons of agricultural products annually, which could grow on degraded soils [7].

There are about 3100 thousand hectares of land predisposed to develop erosion processes in Omsk region, of which 1142.8 thousand hectares (17% of all agricultural land) are already subject to destruction and require immediate restoration.

In this regard, the problem of environmental protection is global and therefore must be addressed not only at the level of an enterprise, but also within individual cities, regions and the whole country.
Besides, at the present stage of economic development of all industries, when most of the available resources are in industrial use and their expansion for various reasons is difficult, agricultural producers face great difficulties in conducting economic activities. Therefore, it is more urgent than ever to introduce innovative technologies and processes that allow, in the presence of the same initial conditions, increasing the efficiency of the production process, reaching a new level of profitability and performance [8]. One of the major elements in the solution of these tasks is the use of production wastes, their repeated application, including in the production of new products not connected with the main profile of the industry, related products, creation of conditions for the transition to full or partial self-sufficiency with all resources necessary for production processes.

For agriculture, the introduction of new operating algorithms in terms of increasing the use of production wastes, in addition to the economic component, is required due to the need to ensure food security throughout the country and regions, preserve the environment, optimize the use of land resources, create new jobs and solve many other diverse problems within the framework of sustainable development [9].

It is clear that without close interaction between existing theoretical developments and the creation of practical conditions and incentives for their application, the desired effect will be almost impossible to achieve. First of all, on the basis of the existing classification of crop wastes, it is necessary to develop recommendations on typical approaches to their use and to adapt them in each region of the Russian Federation depending on the peculiarities of agriculture.

According to various classification criteria, the wastes of the crop industry can be defined as safe, solid vegetable wastes obtained from the primary processing of raw materials, which can be fully used for feed, food and technical purposes.

Next, at the level of regional executive authorities it is advisable to conduct the analysis of the most popular, realized, economically justified uses of crop waste, for example, bioenergy; forage production; use as bedding for farm animals; fertilizer and soil protection products; use for the production of construction and insulation materials, in decorative and applied crafts, etc.

It should be noted that the vast majority of the total crop waste accounts for straw (Fig. 2). In this case, it is fully justified to carry out further studies on the possibilities of processing or using this material.

3. Materials and methods
The purpose of the study is to characterize modern technologies for processing agricultural waste and to offer directions for waste integrated management. It is planned to collect information presenting a particular practical interest to agricultural producers, as well as to state and other regulatory bodies in the field of agriculture. The methodological basis of the study included the provisions of various theories and methodologies for the analysis of agricultural sustainability, methods to forecast the
economic development of rural territories. The information base of the study was statistical collections and directories of state and regional statistics bodies, federal and regional regulatory legal acts, expert databases.

4. Results and discussion

Having studied the experience of advanced farms on the secondary use of agricultural waste both in Russia and in foreign countries, it can be noted that the restoration of erosive soils and the increase in the area of fertile land by creating artificial soil is among the promising areas of modern agriculture [10]. One of the options for making a new type of soil is ligno-cellulose waste from agricultural plants and wood.

Besides, this technology can be used in the following areas:
- clean and friendly environment for the cultivation of healthy plants and seedlings;
- agents for improving soil fertility;
- modifying additive for restoration of fertility of agricultural lands;
- improving the fertile qualities of salt marshes;
- restoration of soils contaminated with pesticides and herbicides;
- restoration of soils contaminated with petroleum products after their purification.

The use of methanobacteria for processing agricultural waste is considered a promising technology. This technology is based on the principle that the microorganisms, propagating in any organic residues, produce biogas, which serves a valuable energy raw material for small power plants. Biogas can be used both for household needs and in the form of fuel for agricultural machinery [11]. To obtain it, special tanks are filled with organic waste thus blocking the supply of air. The final product of the fermentation process is gas, which enters the gas reservoirs for subsequent use. In addition, after fermentation, a disinfected substance remains – an organic, odorless substance that can serve as an organic fertilizer.

Crop waste can serve as a fuel source for most rural regions with small forest plantations and no natural gas, in the form of fuel briquettes from straw and husks of cereals, corn and sunflower with a calorific value of about 16 MJ/kg. For comparison, the calorific value of wood on average makes 17.5-19.0 MJ/kg. In Scandinavian countries (Sweden, Denmark), straw briquettes have long been used and produced as an effective source of fuel. The straw can also be used as a filter material. The briquetted straw is laid in concrete channels in front of the treatment facilities as a filter used to clean the household water. As a result, the calorific value increases by 2-3 times due to the deposition of solid inclusions and fat on the straw. Thus, the work of microorganisms in urban wastewater treatment plants is facilitated.

Besides, the existing developments allow replacing about 20% of dry matter with straw during the lactation period and about 30% – two to four weeks before calving in the diet of cows and heifers. In pure form, straw is fed 1.5-2.5 kg of dry matter per head per day.

One method of processing straw is a biological method, which includes silage and yeast. When silting straw, starters from lactic acid bacteria are used. Good results in silage are obtained by the addition of crushed root crops, green mass of herbs, vegetable waste to cutting.

Another biological method of processing straw is yeast, which improves the taste and nutritional properties of straw, enriches the feed mixture with protein and B vitamins, and increases the protein content by almost 2 times.

The second method of processing straw is a chemical method. It is based on the use of various alkalis such as caustic soda, lime, caustic sodium, ash liquor, ammonia water. This method increases digestibility of fiber up to 75-80%.

Moreover, straw meets all the requirements for bedding material, so it can be used for animal bedding. Some enterprises of Omsk region shifted to yard housing of cattle using straw as bedding. In such enterprises, there is an increase in animal productivity and a decrease in the number of cows with mastitis.
Various options have been developed for the use of crop waste in agricultural practices as a source of organic fertilizers. At the same time, the use of straw improves the physicochemical properties of soil, increases the availability of phosphates and the biological activity of soil, and serves a source of nutrients.

The yield of straw, for example barley, at an average yield (20 c/ha) is 35-40 c/ha. Crop remains at the same yield reach 10-15 c/ha. Thus, at an average grain yield (20-30 c/ha) 4.5-6 t/ha of plant residues will be returned to soil with straw, of which 10-15 kg of nitrogen, 5-8 kg – phosphorus (P₂O₅), 18-24 kg – potassium (K₂O), 10-15 kg – calcium, 4-6 kg – magnesium, as well as the corresponding amount of microelements [12].

5. Conclusion

Thus, the survey shows the widest range of possibilities for the use of crop wastes, which, as mentioned above, for various reasons are not being actively used in Russia with an inadequate level of efficiency. Given these disadvantages and the obvious need for an integrated approach to the use of agricultural waste, including crop production, there is a vital need to develop a concept that includes the implementation of diverse measures (organizational, scientific, methodological, economic, outreach, stimulating) aimed at involving all stakeholders (authorities and local governments, scientific institutions, business of all levels) to create mutually beneficial conditions for the introduction of agricultural waste processing technologies.

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