Green technologies of AIC waste recycling

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Abstract. Modern economic models based on constant production of goods and products based on primary resources have led to the problem of accumulation of unnecessary fractions, waste, and reduction of natural resources. The environment is under anthropogenic pressure and is subject to biodiversity decline due to anthropogenic processes. The time has come for a paradigm shift in the worldview of man's place in the environment and his attitude to its use. The accumulated stocks of production and consumption waste should be rationally applied as secondary resources in other industries. To this end, the paper presents new technological solutions within the concept of cyclic economy for the processing of waste from the AIC sphere.

1 Introduction

Traditional linear economic models, practiced by most countries in the world, have already proved ineffective in the climate transition to lean resource and environmental management. The established practices of recycling, disposal of production and consumption waste have led to the formation of many landfills and accumulation of CO^2 in the environment [1]. National statistics shows that the total area of Russian landfills is 40000 km^2, which is approximately equal to the areas of such countries as the Netherlands and Switzerland. The dynamics of rubbish territories is a growth of 400 thousand hectares annually, which by 2050 will occupy 1% of Russia's area.

In the infographic we have compared the area of landfills in Russia and the area of some countries to demonstrate the scale of the impending ecological disaster (Figure 1).

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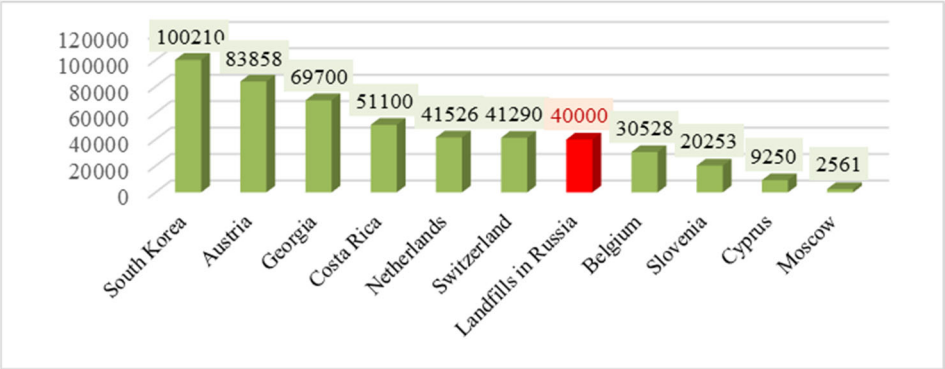

Fig. 1. Comparison of landfill areas in Russia and a number of countries, km^2.

According to the presented figures, the area of landfills in Russia is almost 1.3 times larger than in Belgium, 2 times larger than in Slovenia, 4 times larger than in Cyprus, 15 times larger than in Moscow. These figures actualize the problem of waste accumulation, which partially (up to 60%) can be recycled in the presence and creation of appropriate cyclic infrastructure. This is under the condition of transition to the model of the closed cycle economy (hereinafter referred to as CCE).

In CCE, one of the central approaches is the clear separation of cycles into biological and technical cycles. The main difference in this approach is the clear differentiation between organic components and synthetic components, whose separation after the life cycle of the goods is different. Organics return to the natural environment, i.e., go into the biological cycle for its natural decay, synthetics are directed into the production cycle for reuse, i.e., go through the technical cycle [2, 3].

The sphere of AIC and its production revolves in the biological cycle, i.e., it is the circulation of renewable resources of AIC, LIC, light industry. Raw materials and manufactured goods and products are of natural origin, so after consumption they can be easily returned to the environment for further utilization and enrichment.

2 Materials and methods

The main source of this research is official reporting data posted on the web sites of analyst firms which creates different press releases and ratings. While searching information we reviewed a scientific writings on selected topics of both Russian and foreign researchers and evaluated a dinamics in waste accumulation for the last few years then made a forecasts for future waste accumulation in different industries. Evaluative materials were based on statistical indicators of government and commercial analyst agencies. Empirical tools and methodical apparatus of statistical data processing were used under research.

Structural and functional analysis of reporting materials were chosen as a main method taking into account the peculiarities of development and new trends of technological innovations.

3 Results and discussion

The agro-industrial sector of the economy is quite waste-intensive, as the production of agricultural raw materials is accompanied by the formation of a large amount of waste. The average yield of the main product may be about 15-30%, while the remaining 85-70% may be agricultural waste. The specificity of AIC waste is the presence of many useful

components that can serve as secondary raw materials for additional products in other industries [4, 5].

According to the Ministry of Agriculture of Russia, agricultural enterprises annually generate about 770 million tonnes of waste, including pollutants in the form of emissions of nitric acid, ammonia, fluoride compounds, soot. Substances enter the soil, groundwater, atmosphere and simply accumulate in farms and are subsequently destroyed.

Wastes of the AIC are mostly organic, derived from crop production, animal husbandry and processing industries. As a rule, the following directions of reduction and recycling of such resources are distinguished [7, 8]:

- modernization of applied technologies in the agro-industrial complex;
- reorganization and transfer of processes to waste-free or low-waste cycles of raw material processing;
- development and introduction of innovative technological approaches and solutions in the production of agricultural products and their subsequent processing;
- application of secondary resources in the production of animal feed;
- improvement of equipment at production facilities to reduce losses of raw materials and emissions of harmful substances into the environment;
- building a technological chain from raw material production to its processing and recycling of production and consumption waste.

The optimal solution in this situation would be the creation of an agricultural cluster based on several organizations capable of providing a full agricultural cycle "production-processing-sales-recycling" [9]. [9]. Such a technological solution will reduce the load on the environment, reduce losses in the AIC sphere and additionally stimulate the development of production on secondary resources.

World statistics proves that annually, 1/3 of the produced finished products become food waste. In numerical terms: losses of 1 trillion dollars per year, which can be reduced, minimized or fed to about 2 billion people. Consider the magnitude of these losses (Figure 2).

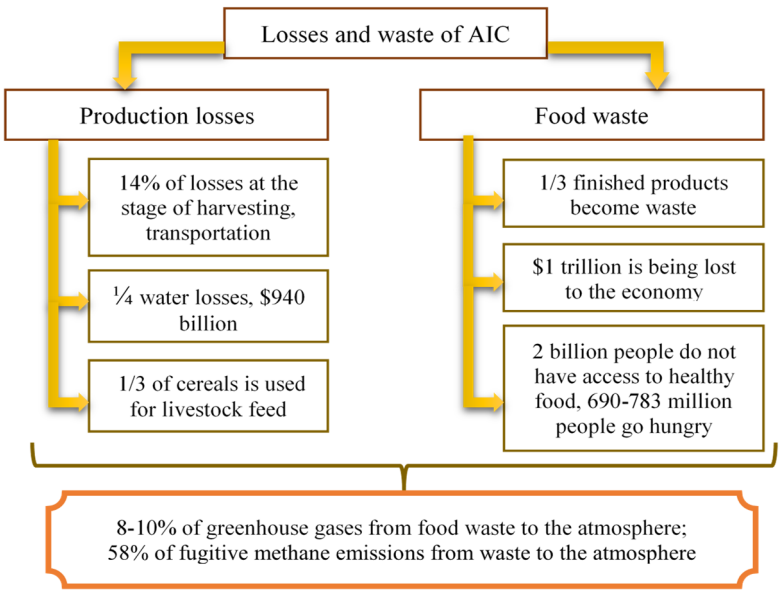

Fig. 2. The volumes of waste and losses in the agribusiness sector in the world.

The presented volumes of losses and wastes in the sphere of AIC prove the relevance of the problem of revising the applied technologies and principles of production, processing, and consumption of agricultural products. The accumulation of harmful environmental impact affects the overall quality of life on the planet and in the long term can generate new mutations of species and the emergence of invasive life forms [10, 11].

Production losses in the AIC are primarily related to the obsolescence of applied technologies and equipment. Therefore, the main problem in this sphere is a technological one, which should be solved at the level of each farm owner. It should stimulate investments in business modernization and updating of applied methods of production, collection, transportation, storage, and processing of agricultural products. Transfer of production to new technologies will reduce not only the cost of external resources, but also save water, energy, and fuels and lubricants, which account for a large share in the total cost of finished products [12]. In addition, prevention of discharges, wastewater spills, by-products of livestock farming into the soil and water bodies will help to maintain the ecological balance in the region.

Food waste is indirectly related to the sphere of AIC, but it is a consequence of processing its raw materials into finished products [13]. The accumulation of this category of waste is associated with various reasons: transport inaccessibility, poor logistics and product planning system, retail errors, lack of rational approach in planning purchases in households. Typically, up to 61% of food waste is attributed to households that are unable to consume the amount of food they purchase due to poor planning and budgeting. Therefore, 17% of all food produced in the world goes into the category of waste and is disposed of in landfills, whereas they can serve in the second cycle as secondary resources if the appropriate infrastructure is in place [14, 15].

As we can see, in the sphere of AIC there are 2 directions of development of the cyclic model of economy — reduction of production losses, processing of food waste. By their content, it is quite possible to combine and build on their basis additional mini-productions for processing and new production of useful goods and products. The general structure of waste in the sphere of agro-industrial complex is presented in the diagram (Figure 3).

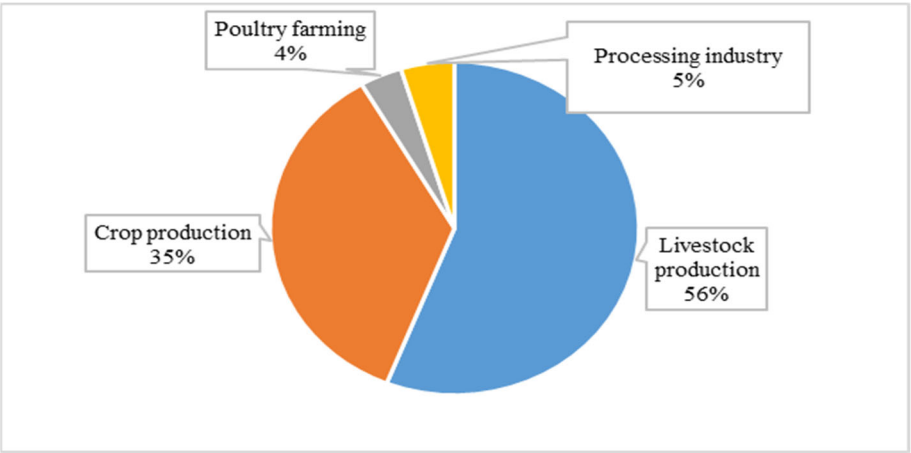

Fig. 3. Structure of AIC waste, %.

We can see that the main share of waste falls on the livestock sector — 56%, the second place is taken by the crop sector — 35%. So it is necessary to pay attention to these areas in the future and look for reserves for reuse of secondary resources.

In the livestock sector, the main by-products are manure and droppings, which also differ in their qualitative composition and origin. The composition of any animal by-product

includes many nutrients that allow its use as an organic fertilizer [16]. For this reason, new technologies of manure preparation for secondary use (express composting, permaculture, anaerobic digestion, thermophilic aerobic stabilization, etc.) are being actively introduced into the production process in foreign countries and in Russia. The second direction of manure utilization is the production of an alternative energy source — biogas.

In crop production, waste is generated during harvesting and primary processing. The main wastes are various plant components of cereal and industrial crops, baskets, and stalks of sunflower, flax bark, corn cob stems, potato and legume haul, haulage and silage wastes, straw, crop residues and others. The main directions of application of such wastes are fodder production, for the formation of bedding material for animals, as part of organic fertilizers and soil-protecting agents, production of construction and insulation materials, in decorative and applied crafts, etc. Also, to solve the problem of production losses, a method of regenerative agriculture has been developed and used, based on the technologies of soil strengthening and restoration, protection of water resources and biodiversity. Regenerative agriculture ultimately increases the overall profitability of agriculture. [17, 18].

The growth of production volumes in all sectors of the national economy, as well as natural reserves of energy carriers (oil, gas, coal) dictate the need to search for alternative energy sources suitable for use in the industrial sector [19]. To this end, the direction of bioenergy production from AIC waste is the most commercially demanded and is actually provided with permanent sources of raw materials. Since the production of food raw materials continues all year round and is dictated by the biological needs of the population. Let us consider in detail the direction and technologies of bioenergy production from agro-industrial waste (Figure 4).

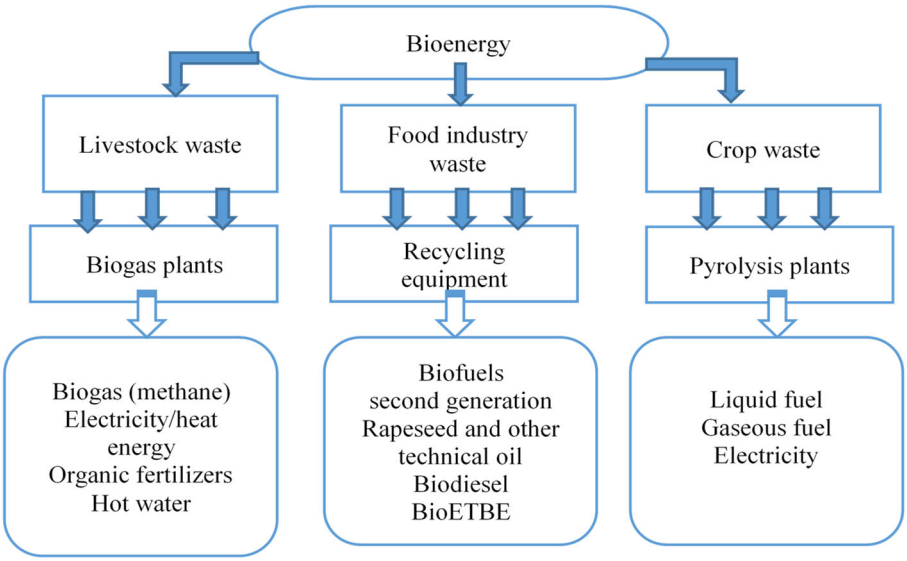

Fig. 4. Directions of bioenergy production from AIC waste.

The presented technologies for processing waste from the AIC sector are in essence bioenergy plants that maximally reduce the anthropogenic load in the areas of production and processing of agricultural products and food industry. At the cyclic approach wastes become secondary resources and sources of valuable biofuels (electricity, heat, steam, motor fuel) on the basis of local renewable raw materials. At the same time it is necessary to combine animal

and crop wastes, depending on the compositions up to 60 biogas technologies have been developed [20].

3 Conclusion

Thus, summarizing our review, it can be stated that quite a lot of work has already been done to reorient the national economy to a new model of closed-cycle economy. During the last years the following activities have been carried out:

- a number of normative-legal acts concerning this issue have been enacted, a system of accounting and control over the movement of secondary resources across the territory of Russia has been formed,
- a list of branches of agricultural production that have potential reserves for the formation of secondary production on their basis has been defined,
- the list of secondary resources that contain many useful fractions for reuse in such areas as fodder production, production of organic fertilizers, bioenergy production, production of other goods and products has been defined,
- developed and applied various green technologies based on secondary resources, which allow modelling the future profile of the market of cyclic goods,
- continues to build a bank of new innovative solutions for the utilization of secondary resources,
- thanks to the work of ecologists, biologists and volunteers, society's attitude towards the environment is being rethought and responsible attitudes towards the disposal of consumer waste are growing.

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