Artículo de investigación

Production and Consumption Waste Sphere Management Modeling

Моделирование Сферы Обращения С Отходами Производства И Потребления

Modelado de esferas de producción y consumo Gestión de residuos

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Abstract

Waste is one of the causes of disturbance of natural biogeochemical cycles, it covers significant areas for storage, pollutes the atmosphere, soil, surface and groundwater with harmful and toxic substances, dust, gaseous emissions. Waste management is crucial in the protection of our natural surroundings. The impact of the situation in the field of waste generation on the overall environmental situation is critical which makes it necessary to take this factor into account when assessing economic development. The environmental situation in Russia is estimated by many environmentalists as critical but stable without any major improvements. According to the Federal State Statistics Service, in the last decade annual discharges into wastewater have decreased (by 15.7% from 2005 to 2015) and so have air pollutants (by 12.7% over the same period), which is explained by the economic crisis (in 2008 and 2015) and some tightening of environmental legislation (increased payments for negative impact on the environment). The article examines methodical approaches to analysing and forecasting the processes in the sphere of handling production and consumption waste. The results of the forecast of the volume of accumulated waste based on the dynamic model of the interindustry balance are presented in the article. It also provides the indicators of total de-consumption by types of economic activity.

Keywords*:* man-caused waste, production and consumer waste, waste processing and neutralization, waste management modeling.

Аннотация

Отходы являются одной из причин нарушения естественных биогеохимических циклов, занимают значительные территории для складирования, загрязняют вредными и токсичными веществами, пылью, газообразными выделениями атмосферу, почву, поверхностные и подземные воды, регулирование их потоков является важной необходимостью для обеспечения благоприятной среды обитания человека. Влияние ситуации в сфере образования отходов на общую экологическую обстановку критично, что обуславливает необходимость учета данного фактора при оценке экономического развития. Экологическая ситуация в России многими экологами оценивается как стабильно негативная, не претерпевающая серьезных улучшений. По данным Росстата за последнее десятилетие сократились ежегодные сбросы в водоемы сточных вод (на 15,7% с 2005 по 2015 гг) и загрязняющих атмосферу веществ (на 12,7% за этот же период), что объясняется кризисными явлениями в экономике (в 2008 и 2015 годах) и некоторым ужесточением природоохранного законодательства (повышением платежей за негативное воздействие на окружающую природную среду). В статье рассматриваются методические подходы к анализу и прогнозированию процессов, происходящих в сфере обращения с отходами производства и потребления. Приведены результаты прогноза объемов накопленных отходов с использованием динамической модели межотраслевого баланса. Рассчитаны показатели полной отходоемкости по видам экономической деятельности.

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Ключевые слова: отходы производства и потребления, техногенные отходы, переработка и обезвреживание отходов, моделирование сферы обращения с отходами

Resumen

Los desechos son una de las razones de la interrupción de los ciclos biogeoquímicos naturales; ocupan grandes áreas de almacenamiento, contaminan la atmósfera, el suelo, las aguas superficiales y subterráneas con sustancias nocivas y tóxicas, polvo, emisiones gaseosas y la regulación de sus flujos es una necesidad importante para garantizar un entorno humano favorable. El impacto de la situación en el campo de la generación de residuos en la situación ambiental general es crítico, lo que requiere tener en cuenta este factor al evaluar el desarrollo económico. Muchos ecologistas evalúan la situación ambiental en Rusia como establemente negativa, no experimentando mejoras importantes. Según el Servicio Federal de Estadísticas del Estado, en la última década, las descargas anuales en aguas residuales (en un 15.7% de 2005 a 2015) y sustancias contaminantes del aire (en un 12.7% durante el mismo período) disminuyeron, lo que se explica por la crisis en la economía (en 2008 y 2015) y un endurecimiento de la legislación ambiental (aumento de los pagos por impacto negativo en el medio ambiente). El artículo analiza enfoques metodológicos para el análisis y pronóstico de procesos que ocurren en el campo de la gestión de residuos de producción y consumo. Se presentan los resultados de pronosticar el volumen de residuos acumulados utilizando un modelo dinámico del equilibrio intersectorial. Se calculan los indicadores de consumo total de residuos por tipos de actividad económica.

Palabras clave: Residuos de producción y consumo, residuos industriales, procesamiento y eliminación de residuos, modelización de la gestión de residuos.

Introduction

According to the State Environmental Protection Report for 2016, the total amount of accumulated and recorded production and consumption waste in the country had made up approximately 31.5 billion tons by the end of 2015 and about 40.7 billion tons by the end of 2016. It should be taken into consideration that the presented figures are of the matter of judgment due to the objective difficulties in waste recycling which appeared many decades ago, as well as in additional accounting of waste at newly identified unorganized dumps. In addition, there are very serious problems in objectively reflecting the consequences of decomposition, weathering, leaching, overgrowing of previously accumulated waste by vegetation.

Out of the total amount of accumulated wastes, the majority according to an approximate estimate (99% in 2016, 98.7% in 2015) belongs to the V hazard class (i.e. with a minimum degree of danger). However, their accumulation damages the natural environment: cluttering of territories, the acquisition of more harmful properties over the time. The rest part classified as dangerous.

However, the amount of greenhouse gas emissions increased by 4% during the same period, even though that was estimated taking into account the processes of absorption by vegetation massifs. The concentrations of many pollutants (solids, nitric oxide, sulfur dioxide, benzopyrene, etc.) in the atmosphere of cities increased or did not decrease because nature does not have time to neutralize the accumulated pollution. Many problems arise when extracting non-renewable natural resources from the bowels while preserving the forest complex and specially protected natural areas (Kontorovich, Eder, Filimonova, Nikitenko, 2018; Babenko, Blam, 2016; Glazyrina, Zabelina, Klevakina, 2014). However, the acutest environmental problem in Russia is the accumulation of production and consumption waste. In this article, we are going to discuss this problem.

The number of enterprises, organizations and institutions in the country in 2016 amounted to more than 5441 million tons. This is 7.5% more than in the previous year, 45% more than in 2010 and 55% more than in 2006. The overall dynamics of the generated production and consumer waste is shown in Fig.1. It should be noted that the statistics in these indicators do not include all the consumption waste but only household waste that is generated in trade enterprises, offices and industrial facilities. Statistics on solid household waste generated in households is shown in cubic meters and only keep accounts of solid garbage, exported from the territories of urban settlements, so the statistics for solid waste is difficult to compare with the indicators above. Consumption waste generated in production along with solid waste form the so-called solid household waste.

The pro-cyclical nature of waste generation as evidenced by the reduction in its volumes in the crisis years is of special interest: by 10% in 2009 and by 2% in 2015 compared to previous years.

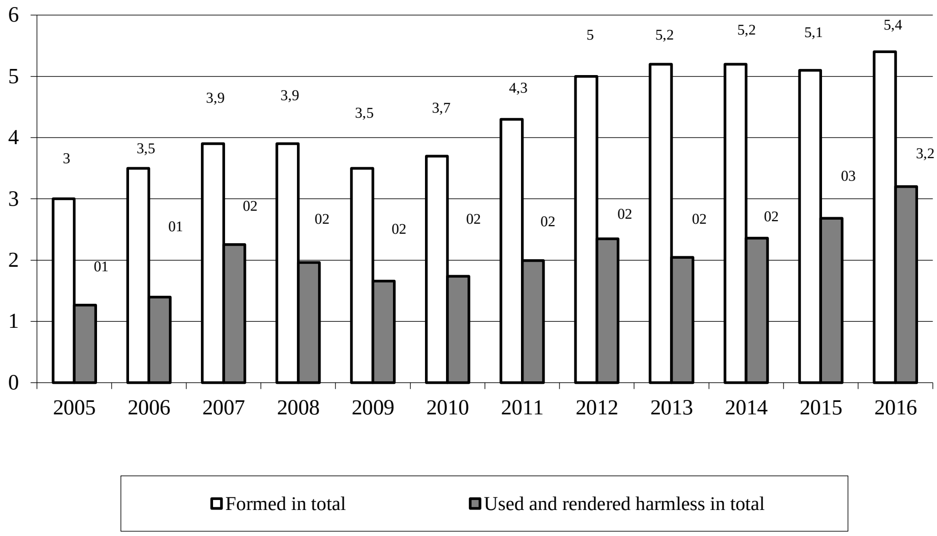

Figure 1. Dynamics of formation, use and rendered harmless of industrial and consumer waste (billion tons). Source: based on Rosstat data.

The current situation of the waste management in Russia is similar to the one in European countries in the 1990s. The real shortage of land and energy resources in Europe contributed to tightening of legislation in the EU countries. Thanks to the introduction of new processing technologies, the EU countries have achieved significant results: there is a steady decline in the burial rate at the landfill sites (up to 40%), the growth of energy production through the use of recyclables and the saving of resources. The total share of processing and use of production and consumption waste in European countries reaches 85-90%. In Russia, on the contrary, during the same period, there was a significant degradation in the waste management system: in the 1990s the Soviet collection, recycling and recycling system was destroyed, and the proper management system for handling it was not created in subsequent years. The share of processing of all production and consumer waste in Russia does not exceed 60% and solid municipal waste is about 2%. Thus, it becomes obvious that the methods for modeling the sphere of waste management need to be developed in order to improve the current situation.

A review of methods for modeling economic development should take into account the ecological component. At the present time, a certain experience has been accumulated in the use of the modeling apparatus in the development of forecasts of environmental activities. Practice shows that the class of balance models reflecting the reproduction of natural resources turned out to be the most suitable for the description of environmental processes, the structure of which is based on the interbranch balance scheme. In the 1960s, the first authors of the mathematical models combining very generalized natural-material and cost equations of the relationship between natural and production processes (Ayres, Kneese, 1961; Daly, 1968) faced the impossibility of practical implementation of the proposed models due to the lack of the necessary information. Part of this problem was solved by W. Isard (Isard, 1972) who attempted to find a solution to this model in 1972 and made a significant contribution to the construction of its database.

The founder of more complex models of this class was V. Leontiev who created in 1970-1973 a model of interbranch balance that is more suitable for practical research and takes into account the environmental sector (Leontiev, Ford, 1972). This model is based on the recognition of the necessity and possibility of including treatment measures (pollution control industries) in the structure of the interbranch balance.

In the further works by V. Leontyev, a more general table of the interbranch balance sheet was presented (the input-output table) which includes the process of manufacturing substances polluting the nature as well as the processes of using primary natural factors and utilized pollutants in the sphere of final consumption.

Model constructions proposed by Leontiev were improved by other economists in order to forecast the economic development of different countries considering the factors of environmental pollution. Dynamic interindustry models that include the environmental costs were proposed in the works of D. Tsukui and I. Murakami (Tsukui, Murakany, 1977) on the basis of regional and national balances with emissions of NOx, SOx and solid waste. One can give many examples of researches in this area which are in progress at the present time (Nansai, Kagawa, 2009; Bouwmeester, Oosterhaven, Duchin, 2010; Bruckner, Wiebe, Lutz, Giljum, 2010; Marin, 2010). However inter-industry methods have not been used actively enough to describe the problems of waste generation and waste accumulation of production and consumer of waste.

The used approaches for modeling the problems of waste management are often the methods of analysis of cost-benefit and life-cycle assessment. In the early models, when making decisions in the field of waste management, the target was to minimize the costs of the system as a whole or its parts (transportation, disposal of waste at landfills) without taking into account the environmental aspects. In the early 1980s the models began to incorporate the environmental component: an analysis of various recycling schemes within the cost minimization approach taking into account the environmental constraints. One of the approaches to the modeling of waste management in solving the above-mentioned problems is mixed integer linear programming (MILP). For example, Jenkins L. used this approach to plan regional solutions in Ontario. The approach makes it possible to identify the best from the considered alternatives in terms of minimizing costs (Huang, Huaicheng, Guangming, 1997). Gottinger H.W. proposed a static model based on integer programming methods that proposes the selection of technologies (their combination and replaceability) providing the optimal solution to the model and carried out calculations for the regional waste management system of the city of Munich (Gottinger, 1986).

A. Huntala presented a model for finding the optimum recycling rate for solid municipal waste and tested it on the data of the Helsinki region in Finland. According to her calculations, the recycling rate of 50% turned out to be economically and ecologically optimal (Huntala, 1997). J. Highfill and M. McAsey presented a theoretical dynamic model of the choice between recycling and landfilling in which it was argued that, given the scarcity of land, recycling is more effective for the municipality even if the current recycling costs are higher than the waste disposal costs because in the future the indirect social costs associated with deteriorating environmental quality, risks to public health through groundwater pollution, etc. will increase (Highfill, McAsey, 2001).

Another area of research is the problem of distributing the responsibility of the parties (producer, consumer, state) in the operation of the waste management system. The costs of waste disposal are regulated through an appropriate system of waste taxation. This model was used in the US to optimize the waste management system. Theoretically, the approach of assigning responsibility to the consumer seems to be effective but in practice, such solutions lead to an increase in illegal landfills (Fullerton, Thomas, Kinnaman, 1994). Another approach that involves responsibility for the manufacturer led to the fact that the studies began to include earlier stages in the life cycle of the product: the processing of raw materials and the production of products. This approach to the evaluation of waste management projects in developed countries was called the life-cycle assessment (LCA). LCA examines environmental aspects and potential impacts throughout the product's lifecycle from the raw material phase to the production, use of the product, and waste disposal. G. Finnveden, J. Johansson and P. Lind compare different solid waste management strategies in Sweden: waste disposal, incineration, processing, fermentation and composting (Finnveden, Johansson, Lind, Moberg, 2005). There are many examples of the use of LCA models for the selection of optimal solutions for waste treatment and disposal (Gentil et all., 2010; Belboom, Digneffe, Renzoni, Germain, Léonard, 2013). The model for assessing the environmental and economic efficiency of solid waste management systems combines both approaches - cost-benefit analysis and life-cycle assessment. The model takes into account all the current and capital costs arising in the waste management system, and the "shadow costs" associated with all types of pollution. When calculating the benefits of the introduction of the system, problems arise in predicting prices, evaluating social effects, and in assessing monetary damage from pollution. However, the model is a synthesis of existing models based on the two approaches and is considered to be an information support tool for decision-making at the corporate, municipal and regional levels (Moutavtchi, Stenis, Hogland, Shepeleva, 2010).

However, all the above-mentioned examples of model approaches solve problems mainly at the regional level and do not use cross-sectoral methods. Still, a rare research based on this method can be found in the special scientific literature. For example, the joint efforts of researchers at Stanford University and the University of Tokyo have developed an environmental model that is an improved version of the Leontiev type models (Pan, Kraines, 2000). One version of the operation of this model takes into account the work

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of the Waste-Processing System but the authors do not give the results of practical calculations on the developed model on the basis of real statistical information from which one can draw a conclusion about the theoretical nature of the model. Our research is distinguished by the use of the intersectoral approach for describing the scope of waste management based on the real statistical information.

The use of interbranch methods in the analysis and forecasting of the sphere of waste management in the Russian Federation

The interindustry analysis allows us to draw the following conclusions. The largest contributors to waste generation are the coal and peat industry, and their contribution has increased significantly over the past decade: in 2006 the share was 49% of the total volume of generated industrial waste, in 2016 it was 62.1%. A large amount of waste is generated when extracting metallic ores (24.3% of the total amount of waste in 2006 and 17.6% in 2016). The share of mining of other minerals accounts for about 7-10%. Of these almost no waste is generated in the extraction of crude oil and natural gas (less than 1% of total waste) but the contribution of the extraction of other non-energy minerals (stone, gravel, sand, clay, phosphates, potassium salts, etc.) is quite large (6 -9%). After the branches of the fuel and energy complex follow the metallurgy, which accounts for 3-5% of the total volume of waste generation. The direct generation rates of waste in the sphere of activity *i* (g_i) have been calculated. They show the amount of waste which is generated while producing the unit of output in the industry *i* and can be calculated using the formula:

$$g_i = \frac{G_i}{X_i},$$

where G_i is the volume of waste generation in the industry *i*, X_i is the volume of production in the industry *i*. Direct coefficients of waste generation are called the indicators of direct waste-to-production ratio. Sometimes, depending on the information used, they are calculated per unit of gross value added (GVA), for the national economy as a whole - per unit of GDP.

We also made calculations of the full waste generation coefficients (indicators of full waste capacity) that are based on the concept of full costs of the interbranch balance. The full waste generation rates for the industry j (fg_j) show the amount of generated waste produced by manufacturing the final output unit in industry *j*, taking into account all cross-sectoral interrelationships. The considered coefficients cover both the direct generation of waste at the final stage of manufacturing the final product unit, and all the contamination at the previous stages of production of this unit of production. The calculation of full waste generation rates can be obtained as follows:

$$fg_j = \sum_{i=1}^{n} g_i b_{ij},$$

Table 1. Direct and full production and consumer waste generation ratios in 2016.

Type of economic acrivity	Indicators of waste capacity (kg per 1,000 rubles of gross output)		Excess of full indicators over direct ones (times)
	direct	full	
Agriculture, forestry, hunting, fishing	7.5	29.8	4.0
Stone coal, brown coal and peat mining	3910.7	4773.0	1.2
Crude oil and natural gas production	1.4	17.4	12.8
Metal ores mining industry	1883.1	1959.6	1.0
Extraction of other mineral resources	577.4	609.9	1.1
Food production	3.4	35.9	10.5
Tobacco products production	0.1	28.1	219.6
Textile fabrication	1194.5	1571.0	1.3

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Clothing and furs production	19.0	465.5	24.6
Leather and leather goods production	4.2	114.0	26.9
Woodworking and wood handicrafts production except for furniture	8.0	38.9	4.9
Industry of wood pulp, groundwood, paper, cardboard products	6.4	60.8	9.5
Printing and publishing industry	0.2	29.1	125.4
Manufacture of coke and refined petroleum products	0.1	43.0	609.0
Chemical production	5.4	57.7	10.7
Manufacture of rubber and plastic products	0.3	60.3	205.5
Manufacture of other non-metallic mineral products	19.3	144.2	7.5
Metal manufacture	38.9	435.3	11.2
Metalware production	2.9	176.9	61.8
Machinery production	0.6	101.3	181.6
Manufacture of computers, electric and optical products	1.8	47.1	25.9
Electric system production	6.9	147.5	21.2
Manufacture of cars, trailers and semi-trailers	0.9	90.6	104.2
Manufacture of vessels, areo- and spacetechnics and other transport means	0.3	69.0	267.9
Manufacture of furniture and other products	0.3	172.1	629.3
Generation and distribution of power, gas and water	3.7	130.4	34.8
Construction	2.2	68.8	31.3
Trandport and communication	0.2	22.0	89.3
Public, social and other services	1.1	15.0	13.8

Source: based on calculations.

It is noteworthy that in some spheres of economic activity the full coefficients are hundreds of times higher than direct ones, for example: in the production of tobacco products - 220 times, coke and petroleum products - 609 times, rubber and plastic products - 206 times, ships and flying vehicles - 268 times, furniture - 629 times. Thus, the methodology of full coefficients allows us to determine the true sectoral load on the environment in the form of environmental violations under consideration.

Based on the results of the calculations of the direct waste generation coefficients, the most sensitive areas of economic activity have been identified: the branches that produce coal and peat, metal ores, other non-energy minerals, and textile production. If we consider the formation of waste taking into account all interbranch relations, we will get the following most polluting industries: clothes and furs, leather and leather products, nonmetallic mineral products, metallurgical production, production of finished metal products, electrical machines and electrical equipment, furniture production and distribution of electricity, gas and water.

A method was also proposed for estimating the generation of waste and placing it in the natural environment using the model of the interbranch balance sheet that allows the forecasting of the creation of gross added value in the spheres of economic activity and GDP as a whole. An ecological block is attached to the interbranch model, which describes the processes of formation, processing and catching of waste using the equations proposed below.

On the basis of the output of industries of different types of economic activity (X_i, $i = 1, ..., n$), using the direct generation of waste g_i attributable to the production of a unit of industry *i*, the volume of waste generation is determined directly in the production process (*G*):

$$G(t) = \sum_{i}^{n} X_i(t) \cdot g_i(t) + D(t)$$

$$(t = \overline{1,T}),$$

where *D (t)* is the generation of municipal waste in households in year *t*.
The equation describing the volume of waste disposal in the natural environment (increment of waste accumulation - ΔN) in year *t* is determined by the formula:

$$\Delta N(t) = G(t) - U(t),$$

where $U(t)$ is the volume of recycled or neutralized waste in year *t*, which in turn is defined as $U(t) = \sum_{i}^{n} \gamma_i(t) G_i(t),$ where $\gamma_i(t)$ is the share of waste treatment or disposal in industry i in the total volume of its generation in the production process.

With the help of the interbranch model with an environmental block, a forecast was made for the accumulation of waste for the period from 2017 to 2020 in the Russian Federation.

Analysis of the results

For calculations on the interbranch model, the key assumptions regarding the economic development of the Russian Federation until 2020, formulated by the staff of the Institute for Economic Forecasting of the Russian Academy of Sciences (INP) (Quarterly forecast of the indicators of the Russian economy: 2015-2020) were used. The forecast is based on the results of macroeconomic modeling that was performed on the G7 software (Almon, 2012). The forecast of the INP is based on one of three scenarios of the socio-economic development of Russia until 2020 - the inertial one. According to it, the preservation of raw-materials export model is combined with decelerating hydrocarbon production and exports, the competitiveness of manufacturing industries is reduced, and the dependence on imports of goods and technologies is growing. The choice of this variant is determined by a number of economic difficulties.

Among them are the favorable conditions in the Russian reality for the "inflation swing", that is, the situation in which inflation, having fallen to the minimum values, could return to the background rates of 3.5-4%. This creates risks of lowering real wages in the private sector with a significant lag inherent in business. Another precondition was the situation of excessive real interest rates on loans that continue to be a key factor in containing domestic demand in the market. In addition to the factors listed above, the low rates of domestic demand and manufacturing growth make the economy increasingly dependent on the commodity sector, which, in the context of stagnant oil production, further inhibits the economic growth.

According to the expectations of the team of INP RAS, these negative factors will be compensated by the growth of salaries in the budgetary sector and the increase in social benefits. The measures containing the extreme strengthening of the ruble are also expected to support the economy. As for the ongoing sanctions, they can have a positive impact on the Russian economy, as it was before. However, the final transition of the Russian economy to the stage of sustainable growth in 2018 is not expected, because the parameters of the monetary and budgetary policy do not correspond to the long-term development goals.

In the framework of the inertial scenario under consideration, the cumulative GDP growth in Russia in 2018 will be 101.2%, in 2019 - 102.4% and in 2020 - 102.3% (see Table 2). In general, the inertial scenario of economic development does not allow overcoming the consequences of the economic recession of 2014-2016 during the entire forecast period.

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Table 2. GDP and GVA growth rate by types of economic activity, %.

Types of economic activity	2017	2018	2019	2020
Agriculture, hunting, fishing	1,2	2,3	2,5	2,5
Mining operations	1,4	1,1	1,6	1,3
Manufacturing activity	0,4	1,3	1,5	1,5
Electrical and water service	0,3	0,7	1,1	1,1
GDP	1,5	1,2	2,4	2,3

Source: Based on RAS data
(Quarterly forecast of the indicators of the Russian economy: 2015-2020).

Ecological parameters used in calculations for the ecological block of the model are presented in Table 3. Forecasting of the ecological load was carried out in accordance with two hypotheses. "Hypothesis 1" presupposes the preservation of waste processing technologies at the existing level throughout the forecasted period (sectoral factors for processing and neutralizing wastes were taken at the level of 2015). Also, Hypothesis 2 was considered, consisting in the assumption that by the end of 2020 the share of waste processing will increase from 53% to 70% in the economy as a whole, the average annual increase in waste disposal volumes will amount to 7.2% (according to Hypothesis 1 - 1.4 %).
According to both hypotheses, the assumption is made about the invariability of production technologies from the point of view of their influence on the quality of the environment (the de-intensities are taken at the level of 2015 and do not change during the forecast period). Also, the calculations do not take into account the removal of domestic garbage from urban areas (D (t) = 0), t. Russian statistics provide such information in volume units (cubic meters), in order to translate which into tons, it is necessary to know the structure of domestic garbage, the data on which is very contradictory.

Table 3. Ecological parameters of 2015.

Indicators	Total	Agriculture, hunting and forestry	Mining operations	Manufacturing activity	Electrical and water service	Other areas
Waste production, mln t	5060,2	45,8	4653,0	282,9	26,4	52,1
Waste production indicators, t per rouble GVA	67,68	14,30	644,68	27,48	11,88	1,01
Part of waste processing and neutralization, %	53	83	53	47	23	65

Source: based on Rosstat data and calculations by authors.

The intake of production and consumption at the beginning of the period under consideration amounted to 67.68 tons per 1 ruble of GDP. If in 2015, according to Rosstat, the volume of generation of production and consumption was 5060.2 million tons, then by the end of the forecast period it will grow to 5434 million tons (by 7.4% compared to 2015).

Waste generation is concentrated in the field of "Mining" and accounts for 91% of the total volume of generated waste in 2020 (see Fig.2). There is nothing surprising about that as the high level of waste has always been and remains inherent in mining and processing. With the growth of mining operations, the production of waste will increase, and much faster than the production. First of all, this is due to a constant decrease in the content of useful components in ores, an increase in the ash content of coal, a complication in the conditions for the development of deposits and, accordingly, the yield of dumping and overburden rocks increases.

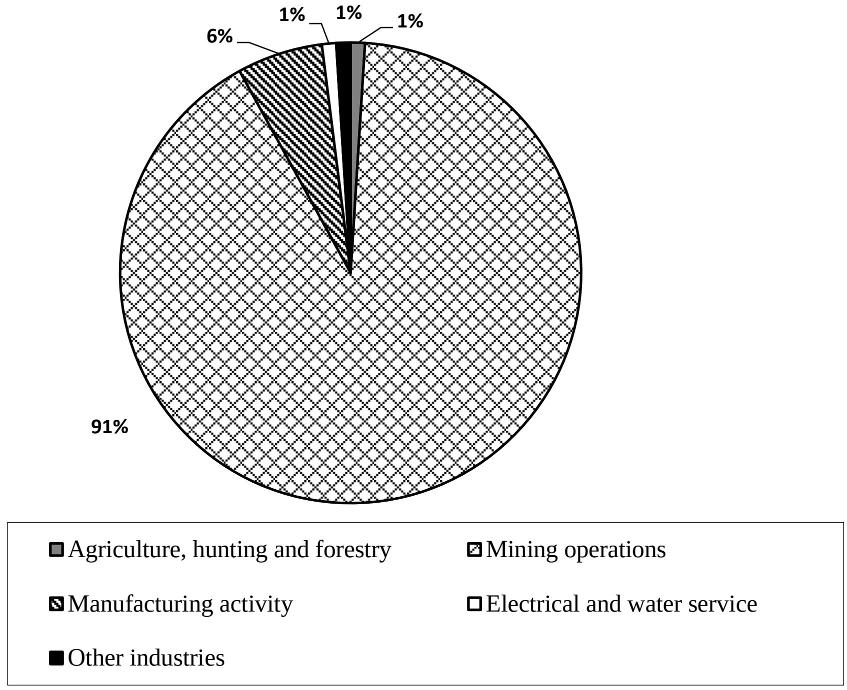

Figure 2. Structure of generation of production and consumer wastes in 2020 by types of economic activity (%). Source: based on the results of forecast calculations.

The forecast of the dynamics of the volumes of formation, processing and growth of accumulation in the environment of production and consumer wastes in accordance with accepted hypotheses (see Fig.3 and 4) was conducted.

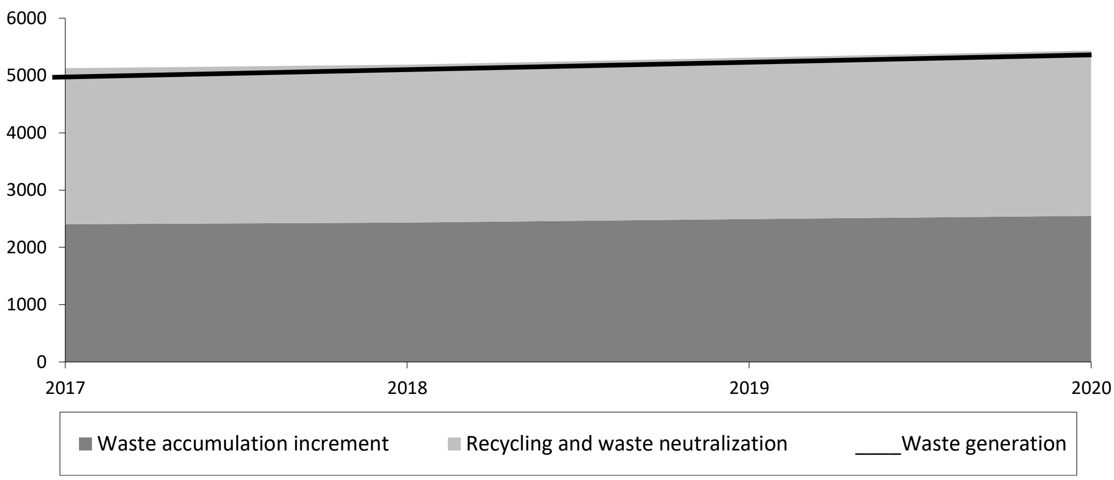

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Figure 3. Predictive dynamics of generation, use and growth of waste accumulation according to Hypothesis 1 (million tons). Source: based on the results of forecast calculations.

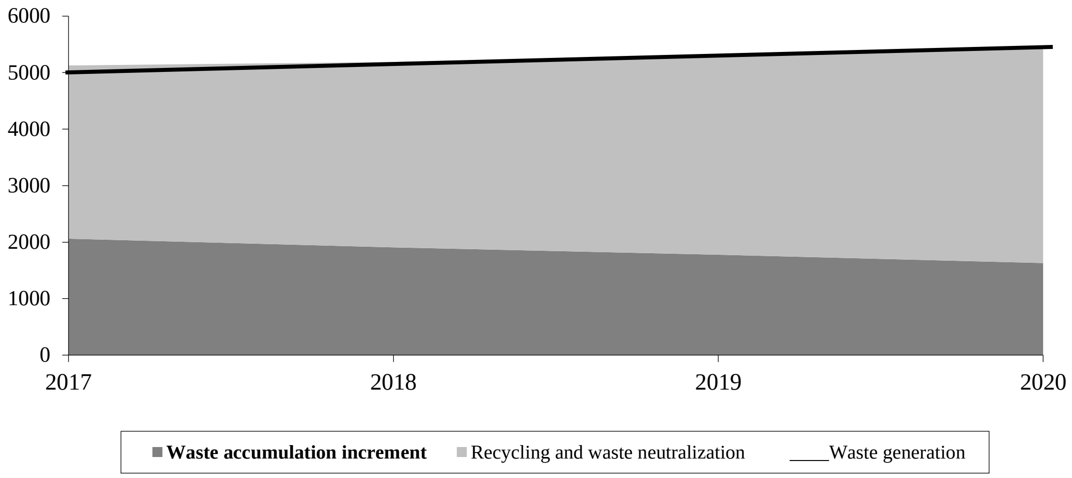

Figure 4. Predictive dynamics of the formation, use and growth of waste accumulation according to Hypothesis 2 (million tons). Source: based on the results of forecast calculations.

According to Hypothesis 1, there will be a small increase in waste disposal volumes. Strengthening environmental activities (Hypothesis 2) will increase the volume of liquidation by 41% by 2020 compared to 2015. Thus, the increase in the scale of waste processing and neutralization will significantly reduce the burden on the environment: according to Hypothesis 1, the increase in waste accumulation over 4 years will amount to 9,884.5 million tons, according to Hypothesis 2 - by 25.4% less (7373.9 million tons).

Discussion

The problem of waste disposal is currently not only a socio-economic one, waste disposal management solves the important tasks in the field of nature protection and also technological tasks (technogenic accumulation of waste can be considered as a resource base capable of replenishing traditional types of mineral raw materials). It is especially relevant for the Russian Federation with its vast territories and a large number of free lands, creating the illusion of an unlimited possibility for accumulating waste. As it has already been noted, although waste from fuel, energy and metallurgy activities is mainly classified as the V class of danger, it still damages the natural environment. According to the State Environmental Protection Report for 2016, more than 500,000 hectares of land are used for storing mining and industrial waste in Russia in general, and the negative impact of the waste on the environment is manifested on the territory that exceeds that area by a factor of 10-15. Approximately 10 thousand hectares of land suitable for agriculture are annually alienated under the landfills. Thus, the useful processing of man-made waste will make it possible to free the area occupied by the dumps and will improve the ecological situation in and around the dump area.

Conclusions

In the developed countries, the use of technogenic deposits is based to a greater degree of environmental, rather than economic, reasons. The requirements of the environmental legislation for reclamation of the disturbed lands and restoration of the natural landscape stimulate mining and metallurgical companies to reuse their waste. In the economically developed countries, up to 80% of building materials (portland cement, gypsum and other binding materials) are produced from overburden, up to 30% of copper are produced of copper ore piles, while processing of titanomagnetite ores, vanadium is extracted, sulphite copper ores - selenium, polymetallic ores - cadmium , thallium, indium. As it has already been mentioned, in the world the indicator of the using man-caused waste reaches 85-90%. The Russian economy lags far behind: not more than 60% of the waste is utilized.

Despite the backlog of Russian technologies in the sphere of waste processing from the developed countries, it is necessary to note some positive trends. The activity has intensified: according to Rosprirodnadzor, in January 2017, the total number of licenses issued in Russia for activities in the field of waste management (including those issued earlier) reached 30,000 units (in January 2016, about 11,700), that means that in the year it had grown almost 3 times. The amount of used and neutralized production and consumer waste in the country in general increased from 1396 million tons in 2006 to 2685 million tons in 2015: in ten years the increase was almost two-fold. In 2016 this growth continued: the corresponding amount was 3244 million tons or 2.3 times more than in 2006 and 21% more than in 2015. At the same time, the level of use and decontamination of production and consumption waste in relation to the volume of their generation increased from 40% in 2006 to 53% in 2015 and to 60% in 2016. It is necessary to keep on increasing the indicator to reach the level of the developed countries.

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