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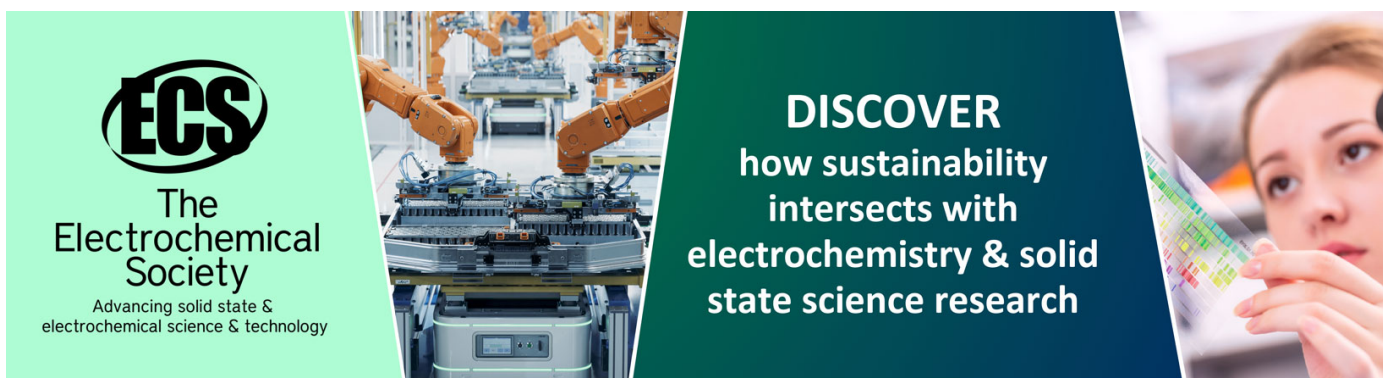
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Ecological engineering as a way to reduce industrial waste

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Abstract. The annually increasing volume of human consumption entails a constant increase in the volume of consumption waste and industrial waste as a result of the need to meet the growing demand. The commodity dependence of the Russian economy only aggravates this problem, since the mining industry is the main source of industrial waste generation. The share of recycled waste tends to decrease, and the share of waste disposed in the territories owned by enterprises is growing. One of the modern methods for solving environmental problems is ecological engineering, which promotes environmentally friendly decision-making and is accompanied by the development of environmental programs as part of industrial enterprise engineering, which, along with increasing the production efficiency and performance, reduce the generation of harmful and hazardous waste. Therefore, in order to achieve production goals, it is necessary to identify the needs of target markets and ensure that demand for them is met through the use of more efficient, cost efficient and environmentally friendly means of production.

One of the most important global environmental problems at the present time is waste management [1-4].

The level of human consumption increases annually, and this entails both a direct increase in the volume of the population waste [5-6], and an increase in industrial waste resulting from increasing production volumes to meet growing demand.

In the Russian Federation, this problem is aggravated by the commodity dependence of the economy, which leaves a significantly influences the industrial waste generation in the country, since it is known that the extractive industry is the industry that generates the largest volume of waste [7-8]. In this regard, issues related to the reduction of industrial and consumption waste, their environmentally safe disposal are extremely urgent for the Russian Federation. This is evidenced by a significant number of legislative and regulatory acts in the field of waste management that are currently in force in the country.

National expenditures on environmental protection in the area of “Waste management” in the Russian Federation are the third after such areas as “Waste water collection and treatment” and “Air protection and climate change prevention”.

There is an increase in national expenditures in the area of waste management, and both the amount of expenditures increases (from 51.611 million rubles in 2013 to 79.517 million rubles in 2017, i.e. by 54%), and the share of these expenditures in the total value of national expenditures on environmental protection (from 10.8% in 2013 to 12.1% in 2017).



Business sector accounts for 71.5% of national spending in this area of environmental activities, and the specialized providers of environmental services account for the remaining 28.5%.

Over the period 2013-2017, the final consumption of environmental services increased by 31.8 times, although the total amount of household expenditures for environmental services compared to national expenditures is extremely insignificant, amounting to 1.621 million rubles in 2017.

Despite all this, according to the Federal State Statistics Service, the generation of industrial and consumption waste in the Russian Federation has been steadily increasing over the past five years (2015-2019) (table 1).

Table 1. Dynamics of the volumes of generation, utilization and disposal of industrial and consumption waste in the Russian Federation for 2005-2019.

Years	Waste generation, million tons	Share of hazardous waste in the total waste volume, %	The volume of utilized and neutralized waste, million tons	The share of recycled and neutralized waste in the total volume of waste generated, %
2005	3035.5	4.69	1265.7	41.70
2015	5060.2	2.18	2685.1	53.06
2016	5441.3	1.81	3243.7	59.61
2017	6220.6	1.72	3264.6	52.48
2018	7266.1	1.35	3818.4	52.55
2019	7750.9	1.30	3881.9	50.08

Thus, the volume of waste increased from 5.06 billion tons to 7.75 billion tons, i.e. by 53.2%, and over 15 years - by 2.55 times.

Along with an increase in the generation of industrial and consumption waste, there is an increase in the volume of utilized and neutralized waste - from 1.27 billion tons in 2005 to 2.69 billion tons in 2015, and 3.88 billion tons in 2019. However, the volume of waste generated is increasing faster than the utilized waste volume - in 2015-2019, the rate of increase in the volume of industrial waste amounted to 53%, with an increase in the utilized waste volume by 45%. As a result, the share of recycled waste in the total amount of waste generated has decreased from 53.1% in 2015 to 50.1% in 2019.

At the same time, there is an increase in the volume of waste disposed at facilities owned by enterprises - from 2.08 billion tons in 2005 to 2.33 billion tons in 2015 and 3.8 billion tons in 2019, i.e. by 62.9% in five years and by 83% in 15 years (table 2).

Table 2. Dynamics of disposed production and consumption waste at facilities owned by enterprises for 2005-2019.

Years	Volume of production and consumption waste disposed at facilities owned by enterprises, million tons	Share of disposed waste in storage areas, %	Share of disposed waste in landfills, %
2005	2077.3	80.4	19.6
2015	2333.1	84.8	15.2
2016	2620.8	80.3	19.2
2017	3204.5	74.2	25.8
2018	3575.4	71.2	28.8
2019	3800.8	69.0	31.0

The share of industrial and consumption waste disposed at facilities owned by enterprises increased from 46.1% to 49%. At the same time, 69% of the waste disposed by enterprises in 2019 is located in storage facilities, and only 31% are buried.

Positive dynamics can be traced in the share of hazardous industrial and consumption waste - it decreased from 4.7% in 2005, to 2.2% in 2015, and to 1.3% in 2019, i.e. over 15 years by 3.4%. The largest share of industrial and consumption waste falls on the V class of hazard, which is classified in accordance with legally established criteria as virtually non-hazardous waste.

Analysis of economic activities in the Russian Federation showed that the largest share of industrial and consumption waste generation falls on such an activity as mining - and the share of this activity tends to increase - from 92.0% in 2015 to 93.6% in 2019. At the same time, the share of coal and metal ore mining in 2019 accounts for 67.1% and 22.5%, respectively, of the total amount of industrial and consumption waste generated.

As for the processing industries, here the main activities that generate the largest volume of waste are metallurgy, chemical production, and production of textiles - their shares in 2019 accounted for 52.4%, 14.3%, and 13.9% of the total amount of processing industries waste.

All of the above reflects the relevance of issues related to the need to reduce the volume of industrial and consumption waste, as well as their safe disposal.

One of the modern trends in solving environmental problems is ecological engineering [9-11]. It is a fairly young branch of ecology, although it is part of engineering in itself, since it includes a sequence of steps and procedures similar to those of engineering science, starting with defining goals and objectives, identifying problems, searching for solutions to problems, and ending with choosing the final solution.

The results of the implementation of ecological engineering mechanisms is reducing the impact of adverse environmental factors on the population, improving the quality of the natural environment. Ecological engineering, including a set of engineering techniques and methods, can serve as the basis for solving environmental problems, reducing their severity. Moreover, certain developments of environmental engineering can find application both at the stage of waste generation and at the stage of their disposal.

Eco-engineering is a set of procedures and actions, the result of which is the minimization of damage to the environment, rationalization of the use of natural resources. It is characterized, on the one hand, by the participation of the state, and, on the other hand, by the interaction of entities - "polluters" of the environment - with engineering companies developing projects that help to minimize the harmful effects of human waste on nature.

Ecological engineering is an area closely related to environmental monitoring, controlling, auditing and marketing.

Together, these areas of environmental science make it possible not only to assess the state of the environment (including on the basis of information from measuring instruments), but also contribute to the identification of problems in the field of environmental safety at an early stage and the timely development of ways to solve them.

In the chain of environmental sciences, at the first stage, there are environmental auditing and environmental monitoring, which contribute to the identification of environmental problems at industrial enterprises [12].

At the second stage, environmental marketing is put into action, on the basis of research of which a set of options for solving the identified environmental problems is formed.

And at the final, third, stage, ecological engineering is used, contributing to the development of a specific management decision in the field of environmental safety.

All three stages are accompanied by the implementation of environmental controlling procedures as part of the environmental management of an enterprise.

Thus, eco-engineering is a mechanism for making environmentally sensitive decisions, accompanied by the development of environmental programs as part of industrial enterprise engineering, which, along with an increase in the production efficiency and performance, contribute to the reduction of the generation of harmful and hazardous waste.

The need for environmental studies of production systems is associated with determining the possibility of:

- modernization of technological systems and units by improving their environmental performance;
- development of more advanced production methods and processes through the relationship of indicators "efficiency" and "environmental friendliness";
- identification of more efficient methods for recycling industrial waste.

All other things being equal, products that are more affordable and comparable in quality and the level of environmental safety for humans are more in demand than competitive products. Therefore, in order to achieve production goals, it is necessary to identify the needs of target markets and ensure that demand for them is met through the use of more efficient, cost-efficient and environmentally friendly means of production.

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