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## Challenges to Waste Management System in the Russian Federation

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# Challenges to Waste Management System in the Russian Federation

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**Abstract.** According to environmentalists, ecological situation in the Russian Federation persists as a negative trend showing no signs of improvement. Accumulation of industrial and consumption wastes, which tends to increase every year, seems to be the most problematic issue today. The Russian waste treatment technologies considerably lag behind those in the developed countries where about 90% of waste is utilized. This article addresses sectoral and regional aspects of waste management and presents estimated amounts of generated waste calculated with the use of a dynamic model of intersectoral balance. Calculations have shown that to reduce waste generation rate by a factor of two, it is necessary to increase the share of waste processing and neutralization up to 70% (in 2016 it was 59,6%). Catching up with advanced nations does not seem feasible during the projection period. The article focuses on the priority importance of processing industrial waste which storage requires alienation of large areas of agricultural land.

## 1. Introduction

The issues concerning production and consumption waste treatment have become the most urgent environmental problems in Russia. The solution of these issues is not merely an environmental but also an economic concern since waste recycling creates new products, waste-derived raw materials and energy resources. Generation of energy from industrial waste is becoming urgent these days; therefore, today waste processing can be viewed as a profitable business, and industrial waste is becoming an increasingly valuable resource.

In Russia, the total amount of accumulated and reported waste as of the end of 2015 totaled 31,5 billion tons, whereas in 2016 – about 40,7 billion tons, with 99% of which falling into the 5<sup>th</sup> hazardous waste category (minimum degree of hazard), but the accumulation of such wastes can have serious environmental effects (i.e. littering, environmental damage over time as a result of decomposition and exposure to natural forces) and, ultimately, affect the health of the population; the remaining 1% is reported as hazardous industrial waste. On the whole in Russia, over 500 thousand hectares of lands are set aside for waste storage, and contaminated areas exceed the storage lands ten to fifteen times. Some 10 thousand hectares of agriculturally productive lands are alienated for waste landfills annually [Gosudarstvennyi ..., 2016, 2017].

Today, recycling and neutralization of waste has become one of the key environmental challenges in Russia. Comparative data show that, in the territory of the EU, over 92% of industrial waste is reused (data for 2012), i.e. 36% of the waste is processed/recycled, 4% is used for energy production,



9% is used for technical purposes to stabilize land slopes, reduce landslide risks, restore landscapes, etc., 2% is incinerated, and 48% is landfilled [Porfiryev, Shirov, 2015]. Worldwide, overall utilization rate of industrial waste is somewhat 85–90%, with the Russian economy still lagging far behind: no more than 60% of waste is utilized.

## 2. Methodology

In course of the research, such general scientific methods as a systematic approach (as a general methodological basis), scientific abstraction, logical analysis, systematization methods, and comparative analysis were applied. Besides, the method of economic-mathematical modeling was used, i.e. the dynamic intersectoral model with an environmental protection block, which has been created/built in the Institute of Economics and Industrial Engineering SB RAS. The application of this model has made it possible to forecast the level of pollution, its neutralization as well as pollution trapping, including industrial and consumption waste. The detailed description of the model is given in [Gil'mundinov et al., 2011].

Lots of recent waste management studies use various modeling methods. For example, in the work [Rogge et al., 2017] accumulation of solid waste in the European Union member states is analyzed and the regional model where EU countries are viewed as regions is presented. The paper [Abbott et al., 2017] submits empirical analysis of recycling and waste behaviors using data for the UK local governments from 2004 to 2013. The authors explain recycling behavior using a simple theoretical model. The secondhand markets' impact on waste is estimated empirically using a fixed-effects model in the paper [Fremstad, 2017].

Most waste management models are mainly based on cost-benefit and life-cycle analysis. For example, Jenkins L. used mixed integer linear programming when planning regional decisions in Ontario. This approach allows to evaluate the possible options and select the best one in terms of cost minimization [Huang et al., 1997]. Gottinger H.W. suggested to use a static model on the basis of integer programming methods which makes it possible to choose an optimal waste treatment technology [Gottinger, 1986]. Huntala A. presented a waste management model for determining optimal levels of recycling municipal solid waste and tested it using waste disposal data from the Helsinki region in Finland [Huntala, 1997]. Highfill J. and McAsey M. developed a theoretical dynamic waste management model for making a choice between recycling and landfilling [Highfill, McAsey, 2001]. In the article [Gradus et al., 2017] cost-effectiveness of two different options for plastic waste treatment are compared. The paper evaluates recycling and incineration of plastic waste, using the data for the Netherlands.

Another direction for the research is allocating responsibility for waste management amongst the main agents (i.e. manufacturers, consumers, states, etc.) [Heller, Vatn, 2017]. Theoretically, the approach based on consumer responsibility seems rather effective; however, in practice such decisions might result in the growth of illegal dumping [Fullerton et al., 1994]. Another approach allocating responsibility to manufacturers has caused the researches include earlier stages of product life-cycle: processing of raw materials and product manufacturing. In the developed countries, such an approach for assessing waste management system is known as "life-cycle assessment" [Finnveden et al., 2005; Gentil et al., 2010; Cheng et al., 2010; Belboom et al., 2013].

However, the above-mentioned approaches can be generally applied at a regional level; they are mostly theoretical and do not use intersectoral methods. Still, some researches in this area can be found in scientific literature. The article [Pan, Kraines, 2000] presents a theoretical model – an improved version of a Leontief-type input-output model – considering waste recycling activities. The novelty of the given research is the use of intersectoral approach for waste management modeling on the bases of statistical data.

## 3. Sectoral and regional aspects

The main contributory factors to waste generation in Russia are coal mining and peat extraction which have significantly increased over the last decade: in 2006 their share accounted for 49% of the total

volume of industrial waste, whereas in 2016 – 62,1%. Likewise, extraction and processing of metal ores generates large amounts of waste (in 2006 – 24,3% of the total volume and in 2016 – 17,6%); other minerals amounts to 7-10% of the total volume of extracted minerals in Russia. Wastes generated by the extraction of crude oil and natural gas are insignificant (less than 1% of total industrial waste), whereas non-energy mineral extraction (stone, gravel, sand, clay, phosphates, potash salts, etc.) generates notable amounts of waste (6–9%). Solid waste from metallurgical industries accounts for somewhat 3–5% of the total amount of industrial waste.

When developing the deposits and processing/enriching the minerals, the areas adjacent to the enterprises accumulate solid production wastes (dumps, oxidized ores, sludge in ponds of mine waters neutralization), residues (mineral processing wastes), metallurgical (slags, ashes, etc.) and hydrometallurgical (slimes) processing wastes, etc. The term "technogenic deposit" (congestion of mineral raw materials in the form of man-made wastes from industrial and manufacturing activities) has lately been applied to such type of deposits. Industrial wastes in the form of technogenic deposits can be used in the future, and in part today as an additional source of mineral raw materials. Mining wastes amount to tens of billion tones in Russia. For example, by 2016 in the Urals (i.e. the Republic of Bashkortostan, Perm krai, Sverdlovsk and Chelyabinsk oblasts) nearly 323 million tons of waste, including 305 million tons of waste which falls within V hazardous category, had been generated from the production and primary processing of mineral raw materials [Gosudarstvennyi ..., 2017]. The total content of valuable components accumulated in technogenic deposits over 20–30 years is comparable and sometimes even exceeds the amounts in annually extracted ores. To illustrate, today in a slurry pit/store of Kachkanarsky Ore Mining and Processing Plant in the Central Urals, the accumulated waste from processing and enrichment of titanomagnetite amounts to more than 900 million tons which contain many valuable metals, including scandium, gallium, strontium, and titan. At the same time, the amount of scandium in production waste exceeds 100 thousand tons, which amounts to more than 60% of total world scandium reserves/supply [Makarov, 2000]. Table 1 shows regional indicators on waste management in Russia.

**Table 1.** Regional indicators on generation of production and consumption waste by federal districts.

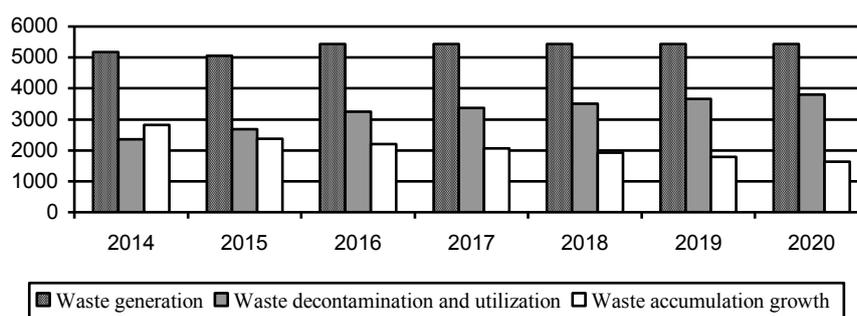
Federal districts/areas	Composition of waste generation (%)		Waste generation per capita (tons per capita)	
	2010	2015	2010	2015
The RF	100,0	100,0	26,14	34,53
Central	5,5	5,1	5,34	6,65
North-Western	8,5	8,6	23,32	31,58
Southern	0,3	0,1	0,86	1,44
North Caucasus	0,1	0,1	0,25	0,25
the Volga Area	2,6	2,9	3,30	5,02
the Urals	6,9	5,4	21,26	22,03
Siberian	67,8	68,6	131,47	179,75
Far Eastern	8,3	8,8	49,45	71,95
The Crimea	-	0,1	-	0,26

*Source:* calculated according to [Okhrana, 2016].

Based on the composition of accumulated waste in the overall volume of industrial waste in Russia and waste generation per capita, one can conclude that Siberian Federal District has been experiencing the most significant environmental strain caused by the increasing rate of waste generation/accumulation: in 2016 the share of Siberian Federal District in the total production waste amounted to 70,2%. Thus by 2016, Siberian Federal District had accumulated over 60% of the total volume of industrial waste generated in Russia (the Urals – about 24%, the Volga Federal Area – about 7%, Far Eastern and Northwestern Federal Districts – less than 5%) [Okhrana ..., 2008, 2016].

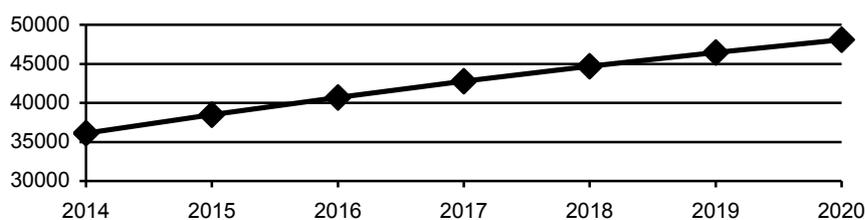
#### 4. Results

Application of a dynamic intersectoral model with an environmental protection block has made it possible to forecast the level of waste arisings and processing and accumulation of production and consumption waste until 2020. The forecast is based on the assumption of modest economic growth in the Russian Federation: 3-4% inflation rate is likely to create risks of real wages decrease in the private sector. Another prerequisite impeding economic growth appeared to be underestimated loan interest rates which are a key restricting factor for the growth of internal consumer demand in the domestic market. Besides, a sustained economic growth does not seem feasible in the foreseeable future since the parameters of fiscal and budget policy do not comply with the purposes of the long-term development. Of course, a certain positive impact on the economy will be observed due to a continuing import substitution policy. Under these conditions, in 2018 real/aggregate GDP in Russia is estimated to grow up to 101,2%, in 2019 – 102,4% and in 2020 – 102,3%. The calculations for the ecological block have shown that in order to achieve an almost twofold decrease in the rates of growth of production and consumption wastes accumulated by the year end (from 6,5% in 2015 to 3,4% in 2020), it is necessary to increase processing and neutralization of industrial waste to 70% (in 2016 it was 59,6%), provided that waste generation level in the considered period will remain the same level as that for 2016. To achieve the level of developed nations (up to 90%) is unlikely within a short projected period/in the short run. The obtained environmental indicators are presented in Figures 1 and 2.



**Figure 1.** Real and estimated indicators of waste management (million of tons). *Source:* Rosstat official data and estimated calculations.

Mining industry is estimated to generate up to 91% of the total amount of waste accumulated in 2020. This is to be expected since high level of contamination has always been inherent in mining and processing industry. Increasing mining and mineral extraction will result in high waste generation and is likely to outpace production growth. This is primarily due to a constant reduction of valuable components in ores, increase in ash-content of coals and complication of field exploitation conditions. Industrial wastes from *technogenic deposits* (i.e. congestion of mineral raw materials in the form of man-made wastes from industrial and manufacturing activity) can be used in the future as additional source of minerals; therefore, processing of such wastes is becoming increasingly urgent.



**Figure 2.** Actual and projected waste accumulation for the period 2014 – 2020 (millions of tons). *Source:* Rosstat official data and estimated calculations.

## 5. Discussion

Waste management requires heavy financial costs. Owing to the lack of adequate investments in the regions of the Russian Federation, the development of waste recycling industry and disposal technologies is still much behind the scale of needs: in 2014 the cost treatment of 1 ton of production and consumption waste in Russia accounted for 11 rubles [Gulin, 2016]. A slight increase in financing waste management in 2016 does not keep up with significant growth of the generated waste amounts. Unfortunately, waste accounting system is still imperfect. The conditions for advanced processing of industrial waste are lacking in Russia; the funds for waste processing and production of waste-derived secondary raw materials is rather limited.

Today there are several objective reasons why potential investors are not interested in the development of technogenic deposits in Russia: lower quality of waste-derived raw materials in comparison with natural deposits, which tends to decrease over time; complexity and high cost of extraction of solid components owing to physical and chemical properties of raw materials; plentiful supply and scarce demand for certain types of raw materials; environmental risks, etc.

To provide incentives for the development of waste-derived raw materials, it is necessary for the government to coordinate all participants involved into the development of technogenic deposits. However, extreme inertness, fragmentation within such organizations, the absence of centralized approach to waste management is now being observed. The specificity of waste processing is so complicated and manifold that it requires special legal and regulatory framework. The problem of normative legal provision of waste management, treatment and processing is that the subsurface users' activity related to the use of industrial waste is, at the same time, subject to the Federal Laws "On subsoil" and "On industrial and consumption waste" belonging to various branches of law and intended for various purposes of state regulation, rational use and expansion of mineral resource base due to wastes generation and decrease in their negative impact on the environment.

The adoption of draft law "On Amendments to the Law of the Russian Federation "On Subsoil" and other related acts and regulations of the Russian Federation designed to stimulate the use of mining wastes" aimed at improving legal regulation on utilization of industrial waste can become one of the first steps to reduce waste generation and promote and mandate waste recycling.

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