Statistical analysis of waste generated in Russia and the EU

Natalia Shchukina

Plekhanov Russian University of Economics, 117997, Moscow, Russia

Abstract. The study is devoted to the analysis of the state of waste generation in Russia and the European Union countries. The volumes of waste generation and recycling in Russia and the EU countries have been assessed. The tendency to increase the volume of waste generated from production and consumption in Russia has been revealed. Most of the waste generated is industrial waste, but the volume of solid household waste generated by the population also continues to increase. The main method of waste disposal in Russia is landfill, while global trends focus on recycling and reuse. Despite global trends of decreasing MSW generation per capita, the accumulation rate in Russia tends to increase. This is due to increasing levels of housing improvement and an increase in the amount of packaging materials. In 2022, about 48% of municipal solid waste is sent for recycling, 19% more than in 2019. Changes in waste management in Russia set the stage for the development of the waste management market.

1 Introduction

The amount of waste generated around the world is increasing every year. Waste is a serious problem for all countries in the world. According to a study by the World Bank [1], about 2.01 billion tonnes of waste were generated around the world in 2016. Globally, around 40% of waste is disposed of in landfills. Approximately 19% are recovered materials through recycling and composting, and 11% are treated through advanced incineration [1].

There are different methods of waste management, such as landfill, recycling, incineration, and recycling. One of the most promising methods can be called recycling. Incineration causes the least damage to the environment, but economic benefits are lost with this method of waste management. Therefore, waste incineration for energy production can be called one of the most promising and economically feasible methods of waste recycling. Although new technologies are emerging and being introduced into the waste management and recycling industry, landfill storage is still the most familiar and standard method for most countries.
2 Methods

To analyse trends in production and consumption waste generation in the European Union and Russia, we estimate the overall series dynamics based on the following statistical indicators:
- absolute chain gains \( \Delta y_t = y_t - y_{t-1} \);
- chain growth rates \( T_t = \frac{y_t}{y_{t-1}} \cdot 100\% \);
- chain growth rates \( K_t = T_t - 100\% \);
- absolute value of one per cent increase \( A_t = \frac{\Delta y_t}{K_t} \);
- average absolute chain growth \( \bar{\Delta y} = \frac{y_n - y_1}{n-1} \);
- average growth rate \( \bar{T} = \sqrt{\frac{y_n}{y_1}} \cdot 100\% \);
- average growth rate \( \bar{K} = \bar{T} - 100\% \);
- the average absolute value of growth 1\% \( \bar{A} = \frac{\bar{\Delta y}}{\bar{K}} \).

In order to construct a forecast of waste generation over the next three years, we construct regression lines as time series trend lines.

3 Results

3.1 Waste management trends in EU countries

Despite the economic difficulties faced by many nations, the steady upward trend in global waste volumes continues. The volume of MSW production has exceeded 1.3 billion tonnes. At the same time, according to the report of the Department of Urban Development of the World Bank [1], by 2025 the amount of MSW generated in the world will increase to 2.2 billion tons. The main contribution to this growth will be made by fast-growing cities in developing countries. Most of the consumption waste is generated by countries with developed economies. Thus, according to the report of the World Bank [5], the countries of the Organization of European Economic Cooperation account for 44 \% in structure of SDW formation. The specific indicator of total waste generation per unit of GDP in the EU countries is presented in Figure 1.

Figure 1 shows that in most Eastern European countries the amount of waste per unit of GDP is significantly higher than the average for all EU countries. For the most developed countries, recycling dominates the waste management system, for Southern and Eastern European countries, recycling dominates. According to the 2021 statistics, the leading recycling rates in the EU countries are Austria (91.53\%), the Netherlands (87.16\%) and Denmark (86.08\%). More and more countries are practising recycling for energy generation.

In 2021, Romania, Latvia, Denmark, Croatia and France used more than 10\% of generated waste for energy generation. Figure 2 shows the structure of waste management in the EU countries.
Fig. 1. Generation of waste excluding major mineral wastes per GDP unit. Source: Author.
According to various estimates, the volume of solid waste generated globally is currently around 3.6 million tonnes per day and could rise to more than 6 million tonnes per day by 2025. The leading countries of the European Union in terms of municipal solid waste collected per capita in 2021 are Austria (834 kg/person), Norway (799 kg/person), Luxembourg (793 kg/person), Denmark (786 kg/person) and Belgium (759 kg/person). Some countries show stabilising and decreasing trends in MSW [2]. The leaders in the reduction of MSW collected per capita from 2012 to 2021 are Bulgaria (-52 kg/person), Sweden (-36 kg/person), the Netherlands (-34 kg/person), Cyprus (-31 kg/person) and Denmark (-20 kg/person). In Russia, the situation is very similar. Every year more than 48 million tonnes of MSW are produced in Russia [1]. The average specific MSW production in the EU countries is shown in Figure 3. According to the data obtained, high income countries are characterised by a high share of waste generation. Figure 3 shows the amount of municipal waste per capita in the EU in 2021.
3.2 Waste management trends in the Russian Federation

Over the past few years, significant changes have been made in the legislation and regulations of the Russian Federation related to waste recycling. The strategy of industrial development on processing, recycling and neutralisation of production and consumption waste for the period up to 2030 [4] provides for increasing the share of recycled and utilised
waste in total waste to 86% by 2030; increasing the share of MSW sent for recycling to 80% by 2030.

According to official statistics [5], in 2022, the country produced 9.017 billion tonnes of industrial and domestic waste, which is 168 kg per person per day. This is 3.4 times more than in 2003 and more than twice as much as in 2011. In 2022, 4.125 billion tonnes of production and consumption waste were recycled and neutralised, accounting for 45.75% of all production and consumption waste generated. The dynamics of waste generation are closely related to the situation in production, as most waste is generated during industrial production. Figure 4 shows the dynamics of production, disposal and burial of production and consumption waste.

![Figure 4](image_url)

According to official statistics [3, 5], the volume of industrial and household waste recycling and disposal has increased significantly in recent years. In physical terms, the volume of production and consumption waste recycling and neutralisation increased 2.45 times compared to 2009. However, the volume of generated waste also increased by 2.57 times during this period. Between 2003 and 2022, the amount of waste sent for recycling and neutralisation ranged from 39.66% in 2006 and 2013 to 56.61% in 2016 of the total production and consumption waste generated. It is therefore premature to speak of an outstripping growth rate in the waste recycling and environmental impact reduction market.

Between 2003 and 2021, the amount of waste produced each year increased by a factor of 3.45, from 2.613 billion tonnes to 9.017 billion tonnes (Figure 4). In 2019, in spite of the COVID-19 restrictions, the total amount of production and consumption waste generated continued to increase. And in 2020, we can observe a slight decrease in the amount of generated waste, which, in general, did not change the overall trend of its increase.

The study of the general trend of production and consumption waste generation allows us to make a disappointing forecast for the coming years. The linear regression equation constructed on the basis of observations for the period from 2003 to 2022, characterising the tendency of waste generation in Russia gives the following result:
\[ y_t = -623.14 + 0.312 \ t, \quad R^2 = 0.925; \quad F = 222.856 \]

Here, \( y_t \) – generation of production and consumption waste, billion tonnes

\( t \) – time point, year,

\( t \)-statistics in brackets below the coefficients are Student’s \( t \)-statistics.

According to the linear regression model built for the optimistic forecast, production and consumption are expected to increase to 8.409 billion tonnes in 2023, 8.721 billion tonnes in 2024 and 9.033 billion tonnes in 2025.

Less optimistic is the scenario with the amount of waste generated according to the exponential model:

\[ y_t = 4.23 \cdot 10^{-54} \exp(0.0618 \cdot t), \quad R^2 = 0.9605; \quad F = 437.849 \]

According to the exponential trend model built, production and consumption are expected to increase to 9.197 billion tonnes in 2023, 9.783 billion tonnes in 2024 and 10.408 billion tonnes in 2025. The results of the forecast models are shown in Figure 5.

![Graph showing data points and trend lines for waste generation]

As we can see, the upward trend in production and consumption waste generation will continue in the coming years. It should be noted that most of the generated waste is industrial waste. Nevertheless, despite the annual decline in the population, the amount of solid household waste also continues to increase. In 2019, there was an average of about 417 kg per person per year, and in 2022 the amount of MSW per capita is more than 313 kg. The greatest amount of waste in 2022 was generated by residents of the Central Federal District. Here there is an average of more than 417 kg of waste per inhabitant per year. The lowest amount of MSW per capita in 2022 was generated in the North Caucasian Federal District. The main indicators of dynamics of MSW generation volumes by federal districts of the Russian Federation are presented in Table 1.
In recent years, the concept of a circular economy and respect for the environment has played an increasing role in international and national policymaking, as well as in consumer behaviour. However, the new waste management methods are complex and include both infrastructure and management, as well as financial and socio-cultural components. The leading constituent entities of the Russian Federation in terms of solid waste generation by an average resident in 2022 are the Leningrad region (954.42 kg/person), the Moscow region (693.06 kg/person) and the Amur region (641.75 kg/person). The smallest amounts of rubbish are generated in the Republic of Buryatia (115.07 kg/person) and Republic of Tyva (164.04 kg/person). At the same time, the basic concept assumes a significant reduction in the amount of MSW generated (from 416.82 kg/person in 2019 to 313.30 kg/person in 2022). For the average resident of the Russian Federation o average rate of increase the average value of the absolute value of 1% increase

Table 1. Volumes of MSW generation per capita (kg/person) and the main indicators of dynamics by federal districts of the Russian Federation

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Source: Author by [3] and [5]

It should be noted that for forty-nine constituent entities of the Russian Federation there has been a downward trend in MSW generation per capita over the last four years. The leading constituent entities of the Russian Federation in terms of solid waste generation by an average resident in 2022 are the Leningrad region (954.42 kg/person), the Moscow region (693.06 kg/person) and the Amur region (641.75 kg/person). The smallest amounts of rubbish are generated in the Republic of Buryatia (115.07 kg/person), Republic of Ingushetia (123.75 kg/person) and Republic of Tyva (164.04 kg/person). At the same time, the highest average absolute increase in the volume of MSW per inhabitant over the period from 2019 to 2022 is 130.75 kg per inhabitant in the Ryazan region (74.49 kg/person in 2019 to 466.75 kg/person in 2022). The smallest absolute increase in MSW amounts to 539.75 kg/person in Kamchatka region. (1986.60 kg/person in 2019 to 367.36 kg/person in 2022). For the average resident of the Russian Federation over the study period there is also a 25% decrease in the amount of MSW generated (from 416.82 kg/person in 2019 to 313.30 kg/person in 2022), which generally indicates a change in the consumption culture of the residents.

4 Conclusion

Taking into account that the waste management industry in Russia is in the formation stage, the objectives outlined in the Strategy [4] assume faster growth in other areas of the Russian economy. At the same time, the basic concept assumes a significant reduction in the amount of generated and buried waste, and an increase in the share of recycled and neutralised waste. However, achievement of the targets is not expected before 2025-2030.

In recent years, the concept of a circular economy and respect for the environment has played an increasing role in international and national policymaking, as well as in consumer behaviour. However, the new waste management methods are complex and include both infrastructure and management, as well as financial and socio-cultural components. The
Further development of the waste management industry in Russia should therefore not only be based on studies and analyses of the individual economic sectors but also on the development of environmentally friendly and conscious consumption by the population and the development of a waste sorting culture.

References


