Circular economy for urban sustainable development: Recycling issues in Russia

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Abstract. The paper is devoted to one of the main issues for modern Russia, namely circular economy and its implementation. Since 2022, a federal project "Circular Economy" has been implemented in the country. It is aimed at environmental protection, waste reduction and recycling as well as increasing the quality of population life. The article focuses on investigating the conditions and factors for the circular economy development in Russia and identifying problems and solutions. The authors study the dynamics of waste accumulation as the result of economic sectors' activity, analyze measures for the circular economy transition, and formulate conclusions on problems and prospects for implementing this model in the modern conditions. The algorithm for creating an urban recycling infrastructure is proposed.

Key words: Urban sustainable development; Recycled waste management; Circular economy.

1 Introduction

Most cities in Russia are currently experiencing a new wave of urbanization. Industry, construction, and transport infrastructure have been developing. However, migration from rural to urban areas brings not only positive results for the economy, but also the increasing waste problem. The need for their processing and modernization of approaches to the secondary raw materials use intensifies the discussion about the role of the circular economy as the basis of the urban socio-economic system.

The circular economy is a worldwide well-known model to limited resources and environmental conservation problem-solving. At present, there is a crisis of human civilization. The growth of population, consumption and extraction of natural resources has led to an imbalance in the relationship between nature and human-being. This could be especially seen in the field of waste management. Plastic used in the goods' packaging or directly in its production is harmful to the environment. It will take over 500 years to decompose in the soil. Annually a huge number of the international events, conferences and seminars are held on the problems of plastic in the nature and its damage to the animal world. A circular economy can reduce such waste and other types of garbage. We are talking about mechanisms for the return of raw materials to the secondary circulation, the

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production of goods from recycled paper, plastic or glass. Russia, unlike developed countries, is only taking the first serious steps along this path. Governmental initiatives and federal programs are realized for circular economy implementation; processing is based on special economic mechanisms stimulating its development; and interaction models between producers, consumers and processors are being formed. The circular economy is closely related to the issue of innovation and new technological and managerial solutions. It is a comprehensive problem that involves the economic, environmental, social and public spheres. Every year Russia faces an increase in consumption and production waste. Therefore, the theme of the circular economy for the national economic system is highly relevant.

The study is aimed at generalizing Russia's experience on the circular economy, studying the main global and Russian trends in the transformation of the economy and the social sphere of cities, including changes in legislation, the implementation of programs and projects to ensure the sustainability of the urban environment. The object of the study is urban areas that are affected by pressure of growing production and consumption, and therefore the problems of waste accumulation and recycling. As a theoretical and methodological basis of the study, general scientific methods of cognition were used, including formal-logical method, systemic, statistical methods of analysis. The circle of structures responsible for the implementation of the circular economy in urban areas was determined using the formal-logical method. The system method made it possible to consider the target groups of the circular economy, to research their role in the process of urban environment changes, needs and opportunities to impact the development of urban systems and their problem-solving. The statistical method was used for the data analysis on waste processing sector. Generally, the research is devoted to the justification of the circular economy model for the modern Russia as the base line for organizing the production and consumption in the country.

2 Recycling and circular economy in Russia

The problem of the circular economy development is the subject of interest for scientists and urban development practitioners as well. In modern Russian science, several directions of the circular economy have been formed. Scientists are studying the mechanisms of circular economy development in the country, its impact on the urban systems' transformation, its role in improving the quality of life of modern cities. For example, Professor Bobylev from Moscow State University connects the circular economy with sustainable development, whose main principles are resource conservation and energy efficiency [1]. Bobylev and Solovyeva note that the circular economy in Russia has already passed the stage of theoretical substantiation and is gradually being introduced into the practice of public and municipal management [1]. There are approaches to studying the circular economy in terms of business models. Pokhomova and Richter consider the circular economy as a system of closed supply chains [2]. This leads to the need to form a new system of consumption in society, gain new competencies for the population, business, and also transform or build social infrastructure in accordance with new requirements to ensure the transition to a circular economy. Potravny considers the problems of environmental damage accumulation in the urban Arctic areas, linking this with the impossibility of exporting waste due to their remoteness and complex logistics. Moreover, the scientist notes that the Arctic cities are experiencing a load on their ecosystem due to the active industrial development of the northern territories, since, according to statistics, the mining sector produces most waste in the country. Potravny suggests that it is necessary to create production capacities for waste processing, primarily in the Arctic region.

The Russian Federation is the largest country in the world, rich in minerals, agricultural and industrial resources. Only the grain harvest in 2022 increased by 26%, i.e., 156 million tons [1]. This means not only an increase in export, but also in waste production. An important problem for the country is the accumulated volume of waste, as well as the lack of production facilities for their processing or disposal. Circular economy has three main elements [2]:

1) producers/manufacturers;
2) processors;
3) assets/resources.

The main task is to organize the interaction between these three elements to ensure the recycling of resources, extend the service life of manufactured goods. Therefore, the main principles of the circular economy are resource saving and energy efficiency [3]. The use of alternative energy sources such as the sun, wind, tides increases the potential to provide energy, and therefore economic security. However, as demonstrated by the results of the energy crisis in the EU, rising prices for energy carriers (gas, oil), and the need to quickly search for new energy suppliers show, alternative energy sources cannot serve as a panacea and completely replace traditional energy [4]. But they greatly facilitate the life of remote villages, switch over part of the costs and consumption of industries, i.e., related activities (lighting, heating, water heating, etc.).

Russia is a leader in mining. For such types of resources as gas, oil, diamonds, the country confidently occupies the first position in the world [5]. Experts note that modern environmental requirements to the subsoil users becomes more stringent every year. If mining company follows all norms and realizes open policy in environment protection the public confidence increases to its business. Therefore, the level of conflicts in the places of their economic activity is reduced [6]. This concerns not only the introduction of innovations in filtration of emissions and water, but also the public control over the activities of subsoil users in local communities. Such experience is actively used in the Arctic [7]. This region is currently a priority for the government, as new mining technologies allow access to previously untouched deposits. Since the Arctic regions are less urbanized, and mostly represented by local communities of the indigenous population. Indigenous peoples conduct traditional nature use, including reindeer herding, fishing, hunting. As the result the traditional lands of indigenous peoples are impacted by industrial development [8]. Therefore, environmental requirements, public control and impact assessment are the main tools to preserve the traditional living standards of indigenous peoples and the environment. However, even such remote settlements could not avoid the problem of household waste accumulation. Garbage dumps are a serious threat to the health of the local population. This also applies to the performance of industrial enterprises [9].

In such a situation, it is necessary to study the issues of waste management and develop recycling mechanisms. Therefore, the circular economy's topic is relevant for Russia. According to Federal Law No. 89 "On Production and Consumption Waste", all waste, depending on the degree of negative impact on the environment, is divided into five hazard classes:

Class I: Extremely hazardous waste;
Class II: Highly hazardous waste;
Class III: Moderately hazardous waste;
Class IV: Low-hazard waste;
Class V: Practically non-hazardous waste.

The transition to a circular economy model in Russia involves the creation of a digital platform for the federal state information system for accounting for waste of I-II hazard class. This is one of the promising directions in the "Ecology" national project implementation. The division into hazard classes implies that different technologies for the

disposal and processing of products for recycling will be applied, which will require the development of domestic innovations in this area, since the transfer of technologies from the most successful countries in the field of recycling (mainly the EU) is currently impossible. Today, there is an acute shortage of hazardous waste processing capacities in the country. In the plans of the state program for the transition to a circular economy, it is planned to recycle 2/3 of hazardous waste and return them to economic circulation. The current situation indicates that only 1/3 of the hazardous waste recycled is only recycled. A significant part of class I-II waste is accumulated in the mining industry.

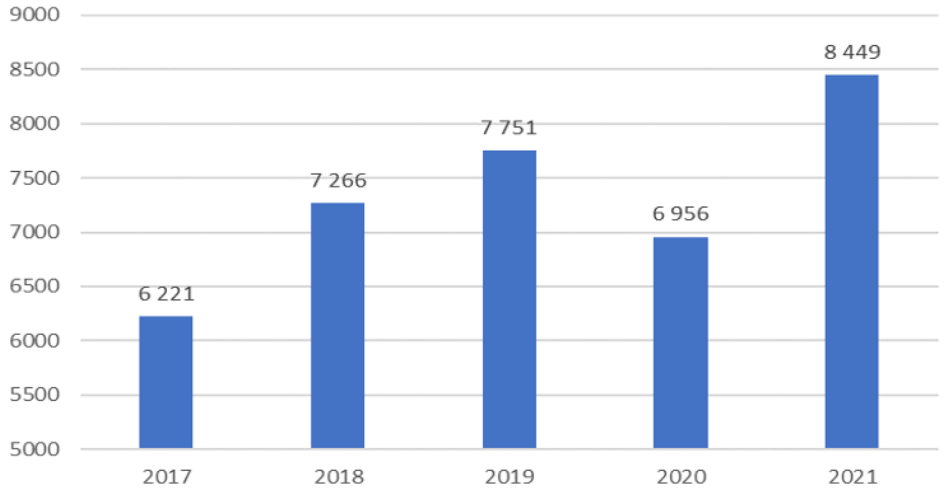

Fig. 1. Production and consumption waste in Russia, million tons (made by authors on [10]).

It should be noted that the largest share of waste in Russia is generated by mining, metallurgy, and manufacturing sectors. Considering that the country's economy has been export-oriented for many years mainly due to the sale of hydrocarbons, the accumulated waste as a result of this activity is enormous. Especially these volumes are accumulated in the Arctic, where a significant proportion of natural resources, oil, gas, diamonds, non-ferrous and rare earth metals are mined [11]. Currently, special programs are being implemented in Russia to clean up the Arctic, and the exported waste amounts to millions of tons.

As can be seen from the dynamics of production and consumption waste generation presented in Fig. 1, their volume is increasing, which means that the number of goods produced is growing. The rase in consumption also indicates the growth of the economy. However, this situation has a downside. The growth of production, economic development should be accompanied by a positive trend in the indicators of waste processing, the use of secondary raw materials.

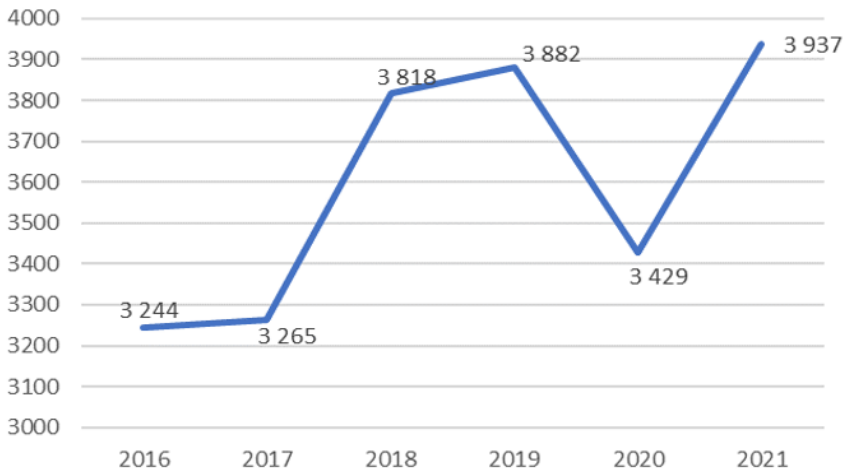

Fig. 2. The production and consumption of wastes in Russia: utilization and neutralization, million tons (made by authors on [12]).

Figure 2 shows the dynamics of utilization and neutralization of production and consumption waste in Russia. When comparing the presented data in Fig. 1 and Fig. 2 it is considered that the waste is not utilized even by half, and the dynamics of this indicator remains the same, without fundamental growth trends. This means that the country has not created enough capacity for waste processing. The initiative of the Government of Russia, announced in 2021, is called to change the situation. Building a circular economy is now a strategic goal; since 2022, the federal project "Circular Economy" has been implemented in the country [13].

The federal project is aimed to achieve 100% waste sorting by 2030. Currently, according to the Federal State Statistics Service, only 38% of waste is sorted in Russia. Recycling figures are very low – only 3.6%, which is unacceptable. Currently, legislation in the field of circular economy is being improved, new environmental requirements, regulations, rules of producer responsibility are being developed.

According to expert estimates, 47.8 million tons were accumulated in Russian cities in 2021. Compared to the previous year, the volume of waste decreased by 4.4%. The leaders in consumption and the main producers of waste in the country are Moscow, the Moscow region, St. Petersburg, and the Krasnodar region. In the Russian urban area, waste production is 434.7 kg per person. Most of the garbage is produced in the cities of Kamchatka and Magadan, and the least in Kyzyl and Elista. Despite the fact that Moscow and St. Petersburg produce the most household waste, the indicators of waste generation per person are much lower than the leaders. However, these data are incomplete, as the problem of illegal dumping remains in cities. Analysts believe that the decrease in household waste is due to the overall decline in the population.

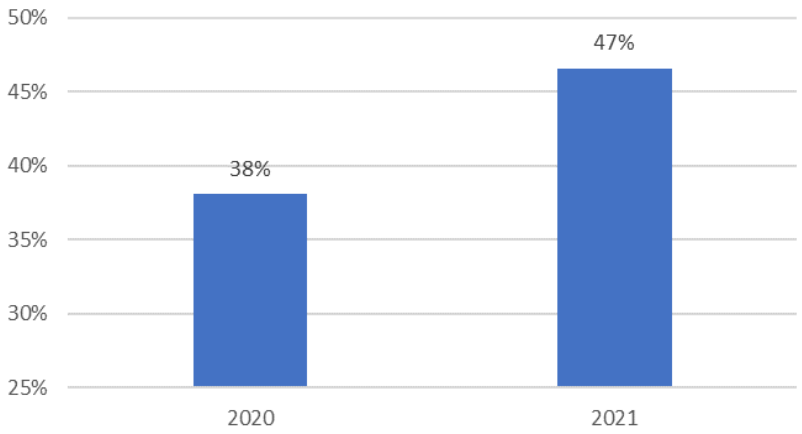

Fig. 3. Dynamics of the share of waste treatment in Russian cities.

Positive trends are an increase in the share of recycled waste in the cities of the country. However, considering current external and internal conditions for the functioning of the Russian financial system, there is a threat of reducing investment in waste processing, creating a waste processing infrastructure that is highly dependent on Western technologies. Therefore, the development of mechanisms that stimulate domestic innovations in the field of waste processing is very important. On the other hand, it is necessary to introduce responsible consumption, improve separate waste collection in cities. This will give an impetus to the production of recycled materials, as supplies to manufacturers of products will be organized and guaranteed.

3 Results and perspectives

The world population growth leads to consumption growth. Consequently, the accumulation of solid waste will never leave the agenda, but will only be updated [16]. Of course, the problems of garbage are relevant for any country. And along with this, there are issues of processing, development of industries based on the secondary use of raw materials, new rules for disposal, and environmental protection. Conventionally, the accumulation of solid household depends on two important aspects [17]:

1. Reasonable and responsible consumption (reduction of consumption or transformation of the consumption system).
2. Recycling of raw materials.

It should be noted that responsible consumer behavior is associated with environmental education, which must be implemented since childhood. Caring for the environment, sorting waste and using environmentally friendly products and packaging are the main areas of education for children and adults [18]. For this purpose, special programs are being implemented in developed countries that shape the future responsible consumer. This is an important waste reduction mechanism. It should be actively implemented in Russia. These should not be one-time actions, but systematic work, built and planned for years to come.

Processing and recycling of raw materials is an economic, environmental and technological problem. The large investments need to be done to entire production-consumption-recycling cycle. The main approaches are technologies development, the innovations approach to the materials production and their recycling. It is necessary to

develop and to implement economic mechanisms for circular economy. One such mechanism is federal projects.

Table 1. Goals of the federal project "Circular Economy" [13].

Goal	Indicator
Biological cycle	Increase from 1% to 15%
Technological cycle	Increase from 5% to 35%
Collection and sorting of waste	Decrease from 94% to 59%

Manufactured products usually contain useful components that can be reused. Therefore, the task of the developed economic model is the return to the economic circulation of raw materials suitable for recycling [19]. The success of the implementation of such a model depends on the partnership of the state, business and the population. Each of these actors must have the desire and motivation for responsible production and consumption. Such a system has been built in developed countries and has proven its effectiveness.

Despite significant advances in the formation of the urban circular economy model, there are limitations to its effective development. Technologies that are based on innovative solutions for recycling, sorting, or re-manufacturing are very costly. Moreover, a country like the Netherlands, which is a leader in the urban circular economy, has imposed sanctions against our country, like other EU members. Such a significant external factor creates barriers to technology transfer. As for the internal prerequisites for the development of a circular economy model in Russian cities, experts say that Russian society is ready to comply with all requirements and norms, and is interested in green stimulation of economic activity. In this regard, the creation of an infrastructure for the availability of separate waste collection in cities is important. The urban economy is a system of interrelated elements, including the population, business, government. The resources of the target groups are used daily for the common goal – the development of the territory. On the other hand, the urban economy is a business model in which suppliers, producers of goods and services are consumer-oriented, whose behavior is determined by income level, subjective preferences, tradition and culture. Therefore, the urban economy should be considered as a socio-economic system that is affected by modern trends, society's demands for a high standard of living on the one hand and limited resources on the other. In this regard, the transition to a circular economy could be a solution to such problems, including the environmental safety of cities.

Thus, the circular economy in cities should begin with the organization of separate collection of waste, its processing and return to economic circulation, i.e., creating production facilities that will operate on the basis of regular guaranteed supplies of secondary raw materials. In order to improve the mechanisms for the separate collection of waste and its processing in cities for the transition to a circular economy, the following algorithm for creating an urban recycling infrastructure could be proposed:

1) establishment of a joint-stock company (JSC) with 50.0001% of the municipality's share of the authorized capital, and 49.999% of the share owned by a business or NGO, ready to participate as a private partner with its own infrastructure;

2) approval of standards for providing cities with the necessary number of recycling points with their subsequent creation. In this case, the following objects will be included in the places of collection of recyclable materials:

- stationary reception points;
- mobile reception points;
- vending machines;
- containers;
- ballot boxes in public places.

The JSC will be able to purchase and provide this property and equipment for use or maintain and operate it itself;

3) organization of logistics to storage/processing points. It is proposed to organize these points on the basis of "urban industrial parks";

4) creation of appropriate facilities for sorting, processing and recycling into final raw materials, as well as infrastructure for storing finished raw materials;

5) organization of the sale of finished raw materials through the "Unified information system in the field of procurement" by means of an open auction;

6) the inclusion of secondary raw materials in production on the basis of own opportunities created or by a private investor.

The developed algorithm will guarantee the manufacturer the supply of a specific type of raw material, within a specific timeframe, in a specific volume, of a specific quality. The primary area of application of secondary raw materials is the sphere of improvement, fuel and energy complex and housing and communal services. The proposed approach is able to fully meet the needs of these socially significant areas.

In general, the creation of a joint-stock company in the field of secondary raw materials recycling will solve several problems, namely:

1) responding to the social demand for the development of separate waste collection;

2) positively affecting the reputation of the authorities, whose main goal is to improve the quality of life of the population;

3) streamlining a unified accounting system for recyclables for proper tariff regulation;

4) creating conditions for the rapid and widespread organization of separate waste collection, environmental education and education;

5) allowing the development of procurement infrastructure;

6) forming a controlled flow of "raw materials" for the development of the "processing industry" and attract investors;

7) increasing the attractiveness of the region for processors;

8) improving the quality of the raw materials obtained through the primary separate collection;

9) strengthening the diverse motivation of citizens for environmentally oriented behavior (programs of green loyalty in the banking sector, chain stores, gas stations, etc.);

10) creating conditions for engaging recyclable materials in the city's economy.

Such an algorithm is universal and can be used in Russian cities. It is characterized by transparency, involvement of target groups in problem-solving of waste accumulation and their recycling as well as allow the cities to create circular chains of economic turnover without any resources' loss.

4 Conclusion

Obviously, the circular economy is relevant for modern Russia. The industrial development and raw materials extraction, the goods' production and their consumption in the growing urban areas. It means that waste is also increasing. The problem-solving of their accumulation is resource saving and energy efficiency. These principles underlie the circular economy model. The idea is to recycle more of the waste and produce new products based on it. In some developed countries, the share of recycling reaches 80–90%, such as Switzerland. However, the achievement of such indicators cannot be instant. This requires going through a long path of production modernization, organization of processing sites, education and enlightenment of the population. Therefore, the government initiative being implemented in Russia is designed for years. Its success depends on various factors, including the development of economic mechanisms that promote the implementation of its core principles. Such approaches can be tax incentives for green business, i.e., an

entrepreneur who uses recycling materials in the production. Consumer green cards can also be introduced. They allow accumulating store or government service bonuses for purchasing goods made by recycling. Scientific developments aimed at recycling waste should also be funded, and inventive activities should be supported by the state. Organizational mechanisms such as partnerships between government, business and civil society are also important because they contribute to the reduction of conflicts and increase literacy in the field of waste management. Also, public-private partnerships can attract investments in the construction of waste processing plants and related infrastructure. Thus, the study of the circular economy in Russia is an important issue on the scientific, political, economic, environmental agenda.

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