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# Environmental protection infrastructure of urbanized territories
## *(as exemplified by the city of Irkutsk)*

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**ABSTRACT**
Environmental protection infrastructure (EPI) within urbanized areas represents a vital component of ecological infrastructure and the contemporary economic urban framework. Its primary structural elements include enterprises and organizations dedicated to: a) the removal, storage, and burial of municipal solid and liquid waste; and b) the collection and processing of the recyclable portion of municipal waste (secondary material resources - SMR). The functioning of environmental protection infrastructure contributes to the recycling of municipal solid waste (paper, secondary polymer materials, secondary textiles, glass, and others) into secondary raw materials. The main goal of EPI is to reduce the environmental impact of waste generated by urban activities on both the surrounding environment and human health. The study area is the city of Irkutsk and its surroundings. Additionally, the operation of this infrastructure plays an important role in incorporating urban secondary raw materials into the economic cycle. The article is based on program and strategic developments involving the author, the results of expeditionary studies on the morphological composition of municipal solid waste, and similar studies and surveys. The methods used in the article include comparative geography, structuring, fieldwork, mapping, questionnaires, and others. The article is based on program and strategic developments involving the author, the results of expeditionary studies on the morphological composition of municipal solid waste, and similar studies.

***Keywords:*** *Environmental Protection infrastructure, Solid municipal waste, Secondary material resources, Irkutsk.*

## 1. INTRODUCTION

Irkutsk serves is the administrative center of Irkutsk oblast in Russia, with an average annual population of approximately 610,000 residents, making it the sixth most populous city in Siberia. The city is a hub of economic activity, hosting over half of the region’s enterprises and organizations, as well as about one-third of its workforce. The share of the city's industrial production accounts for more than a quarter of the regional total. Almost half of the retail and public catering turnover takes place in the regional center. Irkutsk leads the list of territories in the Irkutsk Region in terms of the construction of residential buildings in urbanized areas. The academic scientific community pays due attention to environmental safety and the creation of a high-quality urban environment. The formation of a modern waste management sector, or environmental protection infrastructure, is one of the environmental challenges faced by the city government. It should be noted that the structure and methodological tools for analyzing and evaluating the level of development of environmental protection infrastructure have been a subject of the author's research interests for many years [1]. Developing a modern waste management sector is a key environmental objective for the region. An analysis of current initiatives and strategic plans

for the environmental, social, and economic development of this significant urban area has allowed us to identify several fundamental conditions. Considering these conditions will help advance the goals of sustainable urban development. Sustainable development is understood as a form of ongoing progress that fulfills present needs without compromising the ability of future generations to meet their own requirements [2]. The expertise of geographers in shaping the institutional environment that underpins contemporary sustainable urban development is highly valuable and in great demand [3], [4].

## 2. RESEARCH METHODS

The author used basic geographical tools to study the waste management sector from an infrastructure perspective. First, empirical data was gradually accumulated through fieldwork, legal analysis, and sociological surveys. To analyze the data from a spatial and temporal perspective, the author employed a structural-dynamic approach, cartography, ranking methods, and other techniques. When characterizing the component composition of municipal solid waste (Aleksandrovsky landfill), the European special method of quadrature was used (a sampling area of 25 square meters of the conditional volume of municipal solid waste, from a specific hopper truck, taken from all city administrative districts in turn during the week).

## 3. RESULT AND DISCUSSION

The issue of waste management within the “cleaning industry” presents a complex and promising research avenue, particularly in urbanized areas. The author's approach to waste management is grounded in the scientific and methodological principles of social geography specifically, environmental protection infrastructure. Environmental protection infrastructure (EPI) constitutes a territorial system comprising structures, production facilities, and enterprises involved in waste disposal activities such as recycling, regeneration, recovery, deposition, and neutralization. It also encompasses institutional components, including regulatory and legislative frameworks that support the control and management of waste flows. EPI plays a vital role in maintaining a healthy living environment for residents, promoting the rational utilization of resources and natural surroundings, and contributing to the preservation of attractive landscapes and residential areas [5]. The waste management processes in Irkutsk have been examined from economic and geographical perspectives for over 35 years (**Table 1**). Additionally, there is a dedicated section that addresses measures aimed at developing the information security system, which are reflected in current and strategic program documents at both the city and, in some cases, regional levels.

**Table 1.** Main developed concepts and programs, completed research work (ecological-social-economic direction of the city level, 1991-2024)

| Title of research papers, program-strategic and other documents | Author's participation status, year |
|---|---|
| Research works | |
| Development of scientific foundations for environmental protection measures and rational use of urbanized territories (using Irkutsk as an example) | Responsible executor, 1989 |
| Conceptual foundations for the development of a territorial system for the procurement, processing and neutralization of natural and man-made resources (using Irkutsk as an example) | Scientific management, responsible executor, 1994 |
| Morphological composition of solid municipal waste arriving at the Aleksandrovskii landfill (Irkutsk) | Scientific management, responsible executor, 2007 |
| Potential for selective collection of solid municipal waste in Irkutsk (experience of socio-geographical analysis of the secondary material resources market) | Scientific management, 2009 |
| Development potential of Irkutsk on the platform of "low-carbon cities" | Scientific management, 2022 |
| Programs, strategies | |
| Main directions for ensuring the environmental well-being of the population of Irkutsk until 2005 | Responsible executor, 1999 |
| Municipal Target Program for ensuring environmental safety of the population of Irkutsk for 2007-2010 | Responsible executor, 2006 |
| Concept of ensuring environmental safety in the territory of Irkutsk until 2020 | Responsible executor, 2007 |
| Program of integrated socio-economic development of Irkutsk for 2008-2020 (section "State of the environment and main strategic directions for improving the urban environment") | Responsible executor, 2008 |

| | |
|---|---|
| Strategy for the socio-economic development of Irkutsk for the period until 2030 | Scientific management, 2011 |
| On the state and protection of the environment of the Irkutsk region in 2024. State report (author's map "Environmental protection infrastructure of Irkutsk", explanatory note) | Offer Package, 2022 |
| Concept of ensuring environmental safety in the territory of Irkutsk until 2024 | Offer, 2024 |

In accordance with the research carried out at the Sochava Institute of Geography of the Siberian Branch of the Russian Academy of Sciences, as well as commissioned scientific research, three stages can be determined in the study and formation of urban EPI. The first stage's period is between 1988 and 1997. When developing the scientific foundations of environmental measures in Irkutsk, ensuring the rational use of resources of the urban economic complex of urbanized territories, a section on waste management was developed and included. One of the significant urban facilities was planned by the Pamfilov Housing Academy - a waste incineration plant (on the outskirts of the Sinyushina Gora district). Conceptual foundations for the development of a territorial system for the procurement, processing and neutralization of natural and man-made resources were developed in the early 1990s, updated later, with the advent of market relations.

The second stage's period: 1998 - 2007. The time frame is related to the adoption of the basic Russian law on production and consumption waste (1998) and summing up the results in 10 years. A number of waste management activities were developed and included in the plans for the socio-economic development of Irkutsk. In particular, a city automated waste management system was created as one of the most important activities in the document developed by our institute and adopted by the City Government "Main Directions for Ensuring the Environmental Well-Being of the Population of Irkutsk until 2005". The map showed the following items: a) the size of the storage sites (in hectares); b) the official (legitimate) and unofficial (spontaneous) storage/burial sites for municipal solid waste (MSW); c) the urban and rural storage sites for MSW; d) the urban MSW landfill and the cattle burial ground; and e) the planned MSW facilities. In addition, the location of MSW storage sites was reflected: 1) in ravines, abandoned quarries, 2) in river valleys, streams, and swamps, 3) in areas cleared of forests, and 4) in other locations. By the end of the 1990s, the territorial scheme for the collection and processing of secondary material resources (SMR) in Irkutsk had been characterized. WMR is represented by two groups: non-metallic (paper waste, secondary textiles, secondary polymers, rubber scrap, etc.) and metallic (scrap ferrous and non-ferrous metals). This scheme includes three subsystems: sectoral, regional, and specialized departments (committees). Procurement points and other facilities, in turn, are divided into stationary reception points, mobile reception points, temporary (episodic) reception points, and others. Processing and sub-processing enterprises are represented as production and procurement enterprises, metal scrap packaging sites, bases, etc. The structure of procured secondary raw materials has been dominated by the group of metal secondary raw materials (from 85% to 90% of the total mass of urban procurement). Visual displays for solid waste management are currently being actively used to characterize urban environmental infrastructure.

The third stage's period: 2008-2019. With the adoption of the "Program for the Comprehensive Socio-Economic Development of Irkutsk for 2008-2020", the section "State of the Environment and Main Strategic Directions for Improving the Urban Environment", the block on waste management was constantly updated and supplemented. The museum "At the Dump" (2015) was organized as a citywide facility (the concept and organization by the head of the municipal solid municipal waste landfill of Irkutsk, A. Rastorguev). Two basic research works were completed: "Morphological composition of solid municipal waste arriving at the Aleksandrovskii landfill (Irkutsk)" and "Potential for selective collection of solid municipal waste in Irkutsk: experience of socio-geographical analysis of the secondary material resources market". Two trends should be noted. First, a comparison of the component composition of MSW over the past decades can be formulated in the following way: the highest increase in weight volume is observed for secondary polymer materials and a noticeable decrease in the share of organic waste (respectively, fivefold and twofold in 2018 pre-pandemic year in comparison with 1991). Second, regarding the willingness of the population to participate in the collection of secondary raw materials. The results of sociological surveys conducted in Irkutsk confirm that residents are willing to donate their VMRs, provided that there is adequate transportation to the collection points.

The fourth stage: from 2019 to the present. The sphere of handling solid municipal waste in Irkutsk

was transferred on a competitive basis to the regional operator "RT-NEO". It is necessary to debug the systematic procurement of secondary material resources. Morphological analysis of Irkutsk city waste showed that more than 35% of municipal solid waste (MSW) are potential secondary raw materials and are of commercial interest. The author's thematic map "Environmental protection infrastructure of Irkutsk" presents enterprises and organizations, facilities for handling municipal (communal) waste, including municipal solid waste, liquid household waste (LHW) and others. The predominant part of Irkutsk SPI facilities is made using icons with colors and geometric figures of different scales, which characterize both the capacity and the types of secondary raw materials accepted (for example, metal/non-metal WMP), etc. The information base is data from the official portal of the city of Irkutsk ("environment and development", "urban development", "municipal programs", etc.), waste management sites of waste-producing enterprises and public environmental organizations, results of expeditionary research.

The Institute of the regional operator, which replaced the structures of housing and communal services in 2019, in fact, still transports MSW coming from residents of Irkutsk, as well as enterprises and organizations at the stage: container site – MSW landfill. The system procurement of recyclable waste – secondary material resources, indicated in the current program and strategic documents on territorial development by the regional operator is only planned. Currently, in Irkutsk, the total volume of municipal solid waste (MSW) waste, as well as waste equivalent to MSW, is over 450 thousand tons (2025). The produced flow of urban MSW is deposited at the Alexandrovsky landfill (5th km of the Alexandrovsky Tract). There are several companies operating in the selective (separate) waste collection market, and the volume of VMR blanks in Irkutsk does not exceed 3-5% of the total volume of municipal solid waste produced. One of the main reasons for the limited range of VMP blanks and small volumes is the lack of regional enterprises that process secondary raw materials.

Prospects. A waste recycling plant (WRP) is being constructed, which includes a complex for sorting and processing secondary raw materials, and a technology park for recycling WMR (with an allocated area of approximately 13 hectares in the Angarsk district of the Irkutsk region). This inter-municipal waste recycling complex will serve the cities of Irkutsk, Angarsk, and Shelekhov (with an estimated construction cost of approximately 2 billion rubles, funded by a joint budget (of the Russian Federation and the Irkutsk region). The planned capacity of the MSW facility is 200,000 cubic meters per year, with the possibility of a twofold increase. The MSW facility will be the first industrial facility for MSW recycling in the Irkutsk region.

## 4. CONCLUSION

Participation in scientific research (extra-budgetary funding) provides, first of all, access to primary materials, source documents on the functioning and development prospects of large enterprises, statistical observations in the context of urban districts of the urbanized model territory. Fundamental geographical foundations are in demand in the field of waste management both when performing institutional work (primarily program-strategic, regulatory and legislative documents) and in scientific research. Thus, the "Strategy for the socio-economic development of the Angarsk urban district for the period 2017-2030" (2016) received first place in the all-Russian competition of Strategies for the development of cities that are not the centers of the country's subjects (2017). One of the components of success is the comprehensive examination of the IG SB RAS [6], which included multiple stages of revision of a structural and thematic nature, including waste management.

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## REFERENCES

[1] T. I. Zabortceva, *Regional Infrastructure for Waste Handling*, Novosibirsk: SB RAS Publ., 2005, 125 p.

[2] *The Eastern Vector of Russia: A Chance for a Green Economy in Natural Resource Regions*, Proc. Sci. Seminar, Irkutsk: Institute of Geography, SB RAS Publ., 2016, 247 p.

[3] *Assessment of Modern Factors of Urban Development and Urban Changes in Siberia*, Novosibirsk: Academician Publ. “GEO”, 2011, 213 p.

[4] T. I. Zabortseva and N. M. Sysoeva, *Ecological Safety of the City of Irkutsk: Geographical Aspects*, Irkutsk: Institute of Geography, SB RAS Publ., 2013, 129 p.

[5] T. I. Zabortseva, “Problems of the environmental protection infrastructure of Siberia: economical and geographical approach,” *Izv. Ross. Akad. Nauk. Ser. Geogr.*, no. 5, pp. 47–55, 2015. Available: https://doi.org/10.15356/0373-2444-2014-5-47-55.

[6] *Atlas “Baikal Region: Society and Nature”*, Moscow: Paulsen Publ. House, 2021, 320 p.