Solid Municipal Waste Management Through Social and Environmental Mapping

E A Prelkova¹, V V Zotov¹, P M Karjakina¹

¹Department of Labor protection and environment, Southwest State University, Chelyuskintsev, 19, Kursk, 305004, Russia

E-mail: otios@mail.ru

Abstract. When considering environmental safety issues, much attention is paid to problems related to the management of solid municipal waste in courtyards and landfills. One of the most effective ways to reduce the environmental burden on the environment is to collect waste separately. The relevance of the research topic and the degree of its scientific development give rise to the formulation of a scientific problem as a contradiction between the need for waste management and lack of public awareness of the features of the separate collection system and its absence in residential areas. Solid municipal waste management is based on socio-ecological mapping, which provides an adequate reflection of the environmental situation. The authors have developed a map of equipped sites for separate waste collection on the example of the city of Kursk, which allows you to get information about garbage collection sites both for the city as a whole and for individual neighborhoods.

1. Introduction
The result of civilization is a huge accumulation of solid municipal waste, which has recently become a global environmental problem and becomes a direct threat to the environment and public health. This problem is most acute in large cities. It is necessary to create a new management scheme for waste management to minimize the risks of global environmental problems that directly affect the quality of life of the population, environmental and social security of the urban environment. As its component element, it is possible to use modern information technologies and appropriate software solutions. They allow efficient and timely use of available resources in the management of solid municipal waste, which, in turn, will help to reduce the level of damage to the environment and human health. One of these solutions is socio-ecological mapping, the main task is to adequately reflect the environmental situation, which is constantly influenced by anthropogenic and technogenic factors.

2. Relevance, scientific significance of the issue and a brief literature review
Issues of waste management, including their management, are the focus of such researchers as U. B. Babina [2], P. V. Darulis [6], A. Dering [7], A. V. Malashchenko [11], R. Murray [13], S. M. Naiman [14], I. A. Solomin [19], G. S. Feraru [9], J. Pichtel [16], M. Sundaravadiel [22]. Methods for solving problems arising in the management of solid municipal waste, including assessment of the life cycle of the separate waste collection system and motivation for it, were proposed by D. V. Stalinsky and A. M. Kasimov [20], Y. Chi [4], E. M. Favino, M. Ricci, A. Tornavacca [8].
Aspects of mapping application to socio-ecological problems are considered both in the domestic (V. A. Bokov, R. V. Gorbunov, I. G. Chervanev [3], N. N. Malashikha [12], S. A. Petrov [15], V. I. Sturman [21], S. V. Chistov, I. V. Florinsky [5], S. I. Yakovleva [24]) and foreign (S. P. Gautam, P. S. Bundela, M. K. Pandey, S. Sarsaiya [10], T. Wojturski [23]) literature.

In the works of A. V. Abrosimov, D. B. Nikolsky, L. V. Sheshukova [1], K. E. Shecherbakova [18], the possibilities of geoinformation technologies and satellite images for waste storage are analyzed. However, despite the growing number of publications on this issue, studies that would mutually link the issues of socio-environmental mapping and solid municipal waste management, including separate collection of the latter, have not been developed.

3. Problem statement
The relevance of the research topic and the degree of its scientific development give rise to the formulation of a scientific problem as a contradiction between the need for waste management and the lack of public awareness of the features of the separate collection system and its absence in residential areas.

4. Theoretical and methodological bases of solid municipal waste management
The term "waste" refers to by-products that are generated as a result of various human activities and are subject to disposal. The experience of waste management in Russia does not coincide with the experience of European countries [7]. In the Russian Federation, the term "waste management" refers more to landfill disposal. In European countries, "waste management" involves the use of the latter in various activities [8]. Waste management is a set of measures used to solve the problem of waste management in production and consumption.

New practices of solid municipal waste management are extremely complicated (complex), covering infrastructure, financial, managerial and socio-cultural components [25]. The need for competent management of solid municipal waste is understood both at the state and regional levels [17]. This is reflected in waste management concepts and programs developed in various regions.

Briefly, the hierarchy of waste management can be defined in five positions: avoid; minimize; dispose of; neutralize; and bury. At all stages of waste management, human and environmental safety should be ensured. The first level – avoidance (prevention) assumes that during the production of various products, their operation and at the end of their service life, as little waste as possible should be generated. The second level-reduction (minimization) of solid municipal waste implies a reduction in the amount of waste, reducing its toxicity and content of harmful substances. The third level - recycling (utilization) helps to reduce the amount of natural resources and also use to avoid waste storage at landfills. The fourth level is the processing and disposal of solid municipal waste using waste incineration plants. Fifth level - waste disposal at landfills that meet environmental safety requirements.

Recycling opens the way to huge resource savings. However, in order for waste to have a "second life", it is necessary to establish their separate collection. Separation of the generated waste at the collection stage in accordance with its type, aggregate state and hazard class contributes to creating favorable conditions for the transfer of certain types of waste to specialized organizations for processing and reducing the degree of negative anthropogenic impact on the human environment.

Socio-ecological mapping can be used as a tool for environmental protection in the management of solid municipal waste, which allows creating a spatial model of the territory in a visual topographical form.

5. Assessment of the possibility of using socio-ecological mapping in the issue of separate waste collection
The conducted expert survey (32 representatives of state and municipal authorities, employees of scientific and educational institutions, public and commercial organizations of the Kursk region using the Delphi method with an interval between surveys of 14 days, 2020) shows that the study of the
social comfort of living of the population and the development of measures for managing solid municipal waste in the context of their separate collection is possible using geoinformation technologies. As the latter, socio-ecological mapping is fully justified, thanks to which the integrated map of the natural and ecological comfort of the urban environment is modeled. It allows you to carry out inventory and digitization of container sites, to signal about overflowing tanks and changes in the number of containers on them. It is obvious that the map, compiled by monitoring container sites on local territories using GIS technologies, serves as a tool for identifying the spatial pattern of the placement of areas of social tension in order to quickly respond.

The authors conducted a diagnostic study in Kursk, which occupies the median position in terms of socio-environmental indicators (402 respondents aged 16-70 years, 2019-2020), which showed the following.

First, 90% of the respondents expressed their readiness to sort waste, subject to the introduction of mandatory separate collection. Currently, 58% of residents of Kursk are engaged in sorting household waste, with 19% of respondents sorting household garbage completely, and 39% – partially. The survey showed that 2/3 of respondents feel responsible for the state of the environment in their place of residence.

Secondly, the incentive to sort municipal solid waste for the population of Kursk is the installation of separate garbage collection tanks on container sites, social advertising, and participation in protecting the environment from the harmful effects of waste. Despite a fairly positive trend, respondents shared the problems they face in the process of separate waste collection. So, 30% of respondents consider the main problem to be the lack of space for separate storage of garbage in the house (apartment); 26% indicate that there are not enough or no separate waste collection bins at container sites; 24% noted a long distance to the collection points; 12% need economic incentives and 8% do not see the point in separate waste collection, since the contents of all bins go to one landfill in a common pile.

Third, socio-ecological mapping, according to half of the respondents, helps to stabilize the environment and increase the level of comfort of the environment. This method allows you to visualize container sites, digitize them, graphically display garbage cans and signal their changes. Thus, socio-ecological mapping contributes to the promotion of separate waste collection, which allows it to be used in the management of solid municipal waste.

6. Development of a map of equipped sites for separate waste collection

Based on the conducted empirical research, the authors developed a map of equipped sites for separate waste collection on the example of the city of Kursk. This map allows you to get information about places where solid municipal waste is collected both in the city as a whole and in individual neighborhoods. Thanks to social and environmental mapping, it is possible to conduct an inventory with subsequent digitization of garbage sites. It consists of collecting and entering the following characteristics of a container site into the mapping database: 1) location (address); 2) dimensions (length, width, area); 3) number of containers placed; 4) volume of containers placed.

In total, the city of Kursk has more than 250 sites for the accumulation and further removal of garbage. However, not all of them are designed for separate waste collection. Figure 1 shows the sites for separate collection of solid municipal waste in one of the districts of Kursk – Parkovaya.
In detail, the authors of the article reviewed 5 container sites of the Parkovaya district. At the CP-1P point, there are 10 containers, including 8 for general use, 1 (blue) for paper and cardboard, and 1 (yellow) for plastic bottles. At the CP-2P and CP-4P points, there are 9 and 7 containers, respectively, all for general use. At the CP-3P point, there are 13 containers, 1 of which is intended for plastic bottles, the rest for general use. At the CP-5P point, there are 12 garbage collection containers, including 10 for general use, 1 for paper and cardboard, and 1 for plastic bottles. Figure 2 shows a fragment of a map of equipped sites for separate waste collection in Kursk (the Parkovaya district).

Solid municipal waste from all container sites in the city of Kursk goes to the Starkovo landfill located in the Oktyabrsky district of the Kursk region and included in the state register of waste disposal facilities. The capacity of this landfill allows not only to receive and store, but also to neutralize incoming waste of 2-4 hazard classes across the entire region.

The map of equipped sites for separate waste collection can be implemented in the practice of state and municipal management. It will not only allow you to quickly get the necessary information about
the accumulation of waste at container sites and quickly respond to changes in the situation with them, but also serve as a starting point in solving the issue of waste management.

7. Conclusion

Solid municipal waste management is based on socio-ecological mapping, which can be used to create a spatial model of the territory in a visual topographical form. The authors have developed a map of equipped sites for separate waste collection, which allows you to get information about the collection of solid municipal waste both in the city as a whole and in individual neighborhoods.

8. References

[1] Abrosimov A V, Nikolsky D B and Sheshukova L V 2013 Use of satellite images and geoinformation technologies for monitoring waste storage sites GEOMATICS 1 68-73
[2] Babina Yu B 2007 Features of waste management in the sectoral and regional aspects Resource-saving technologies 22 3-18
[3] Bokov V A, Gorbunov R V and Chervanev I G 2016 Ecological mapping. (Simferopol: Publishing house of IT "ARIAL"). p. 238.
[4] Chi Y 2015 Life cycle assessment of municipal solid waste source-separated collection and integrated waste management systems in Hangzhou, China. Journal of Material Cycles and Waste Management 17-4 695-706
[5] Chistov S V and Florinsky I V 1997 Ecological cartography (Moscow: Publishing house of REFIA) p 134
[6] Darulis P V 2014 Wastes of a regional city Collection and disposal (Smolensk: Smyadyn) p 520
[7] Dering A 2007 Utilization of waste Problems of the environment and natural resources 4 54-55
[8] Favoino Е M, Ricci M and Tornavacca A 2004 Motivating forces for separate waste collection in EU countries Resource-saving technologies 18 15-34
[9] Feraru G S 2007 Strategic Approaches to Industrial Waste Managemen Ecological Systems and Devices 1 8-17
[10] Gautam S P, Bundela P S, Pandey A K, Awasthi M K and Sarsaiya S 2010 Municipal solid waste management in Indian cities International Journal of Environmental Sciences 1-4 591–606
[11] Malashchenko A V 2016 Production waste management Bulletin of the Belarusian State Economic University 2-115 67-74
[12] Malashikhina N N 2004 Strategic management of sustainable environmental and economic development of the regional socio-environmental system News of Higher Educational Institutions North Caucasus Region: Social Sciences 2 73-77
[13] Murray R 2004 Zero Waste: “Zero Waste” - An Alternative Waste Management Concept Ecology and Life 6 16-18
[14] Naiman S M 2016 Waste management and statistical accounting problems Bulletin of Perm National Research Polytechnic University. Applied Ecology. Urban Studies 3-23 5-19
[15] Petrov S A 2020 Use of GIS-technologies in the process of integrated management of municipal solid waste Moscow Economic Journal 2 77-85
[16] Pichtel J 2005 Waste management practices: municipal, hazardous, and industrial (Boca Raton: Taylor & Francis Group) p 688
[17] Prelikova E A, Zotov V V and Yushin V V 2020 Management of Local Community Social Capital when Solving the Problems of Urban Environment Pollution with Solid Municipal Waste IOP Conference Series: Earth and Environmental Science. 459 032065
[18] Shcherbakova K E 2019 Monitoring of solid waste landfills using satellite imagery Student Herald 42-92 17-19
[19] Solomin I A 2017 Management of production and consumption waste (Moscow: Rosinformagroteh) p 112
[20] Stalinsky D V and Kasimov A M 2018 Problems and solutions in the municipal waste management system *Ecology and Industry* 2-55 46-56
[21] Sturman V I 2003 Ecological mapping (Moscow: Aspect Press) p 251
[22] Sundaravadiel M 2003 Sustainable municipal solid waste management in developing countries (Experience of small cities in India) *Resource-saving technologies* 8 15-24
[23] Wojturski T 1977 Importance of vegetation maps for the protection of natural environment *Vegetation science and environmental protection* (Tokyo: Kodansha Ltd.) 45-48
[24] Yakovleva S I 2015 Regional maps of strategic planning *Pskov Regional Journal* 23 98-106
[25] Zhukov V T, Lazarev G E and Chistov S V 2001 Assessment of the ecological state of urban areas based on integrated research methods (Moscow: Publishing House of Moscow State University) p 62

**Acknowledgments**
The work was supported by the Grant of President of the Russian Federation. MK-788.2020.6.