ARTICLE

Green Waste Practices
as Climate Adaptation and Mitigation Actions:
Grassroots Initiatives in Russia

Olga Zakharova,

**Carbon Measurement Test Area in Tyumen' Region (FEWZ-2024-0016),
University of Tyumen (Tyumen, Russian Federation)**

https://orcid.org/0000-0002-1404-4915

Anna Glazkova,

**Carbon Measurement Test Area in Tyumen' Region (FEWZ-2024-0016),
University of Tyumen (Tyumen, Russian Federation)**

https://orcid.org/0000-0001-8409-6457

Abstract. Responding to global climate challenges, states are pursuing mitigation and climate adaptation policies, which requires involvement of all actors ranging from global institutions to the public. This article aims to evaluate green waste practices of nongovernmental organizations in terms of the possibility of incorporating these practices into climate mitigation and adaptation policies. The study focuses on two nongovernmental organizations that have been involved in waste management for more than 10 years and has examined the online posts of these organizations to determine the prevalence of nine green waste practices, as well as subscribers' interest in them. The posts are classified using modern machine learning methods. To train a machine learning classifier, we used a dataset for detecting mentions of green practices in social media posts. The study demonstrated that environmental nongovernmental organizations engage hundreds of people

in green practices aiming to reduce anthropogenic climate impacts or adapt to climate change. The often-mentioned practices (separate waste collection, recycling, and other adaptation activities such as promoting responsible consumption or refusing purchases) can be included in governmental policy. Subscribers are aware of ways to reduce consumption and manage wastes responsibly and they can share their experience with the communities gaining the support of the government. The proposed recommendations are related to broad engagement of grassroots initiatives in climate policy implementation.

Keywords: climate policy; green waste practices; grassroots initiatives; mitigation; adaptation; language model; engagement index.

Table of Contents

Introduction

Responding to global climate challenges, states are pursuing mitigation and climate adaptation policies, which requires involvement of all actors, from global institutions to the public.[1] These policies may be different in various states. For example, the Russian Federation has developed a climate policy with measures aimed at

---

[1] Wang, D., Chen, L., & Dong, L. (2024). A Critical Review of Climate Change Mitigation Policies in the EU – Based on Vertical, Horizontal and Policy Instrument Perspectives. *Journal of Cleaner Production, 467*, Article 142972.

different economic sectors as well as regions.[2] This climate policy also includes support for scientific research on the mechanisms of adaptation to climate change and its consequences, and commercialization of the results obtained.[3] In addition, activities have been developed to monitor and forecast the parameters of the environment and climate and mitigate anthropogenic impacts on the climate.

One of the issues related to Russia's climate policy is waste management.[4] Waste production and delivery results in carbon dioxide emissions, affecting the climate when waste is transported to landfills or incinerated.[5] Landfills contribute to environmental pollution and occupy vast areas that could be used in alternative ways.[6] Furthermore, the production and disposal of things accounts for about 45% of greenhouse gas emissions, so the reuse of waste can affect the overall carbon footprint much more than the direct emissions of waste management.[7] Therefore, to reduce greenhouse gas emissions, resource extraction, and environmental pollution, states are striving to improve waste management practices and to implement new economic models of circular economy.

While studies confirm the effectiveness of citizen participation in waste management,[8] none of Russian strategic documents take into account the potential of cooperation with small businesses, nongovernmental organizations, and citizens for successful implementation of waste management policy. According to the sociological survey, citizens are willing to participate in green waste practices, organize and support environmental activities.[9] However, these practices are not

---

[2]   Presidential Decree No. 812 of October 23, 2023 "On Approval of the Climate Doctrine of the Russian Federation." Collection of Legislation of the Russian Federation, 2023, No. 44, Art. 7865. (In Russian); Order of the Government of the Russian Federation No. 3052-r of October 29, 2021 "On Approval of the Strategy of Socio-Economic Development of the Russian Federation with Low Greenhouse Gas Emissions until 2050." Collection of Legislation of the Russian Federation, 2021, No. 45, Art. 7556. (In Russian).

[3]   Resolution of the Government of the Russian Federation No. 133 of February 8, 2022 "On Approval of the Federal Scientific and Technical Program in the Field of Ecological Development of the Russian Federation and Climate Change for 2021–2030." Collection of Legislation of the Russian Federation, 2022, No. 8, Art. 1151. (In Russian).

[4]   Order of the Government of the Russian Federation No. 3052-r.

[5]   Creutzig, F., et al. (2022). Demand, Services and Social Aspects of Mitigation (Chapter 5). In *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 503–612). Cambridge University Press.

[6]   Guseva, A., & Polishchuk, A. (2017). On Readiness of St. Petersburg Residents to Separate Waste: Recycling of Plastic Waste as Problem of Social Ecology. Scientific Notes of Russian State Hydrometeorological University, *47*, 205–215. (In Russian).

[7]   Firmansyah, F., et al. (2024). Variation in Municipal Solid Waste Generation and Management Across Time and Space. *Resources, Conservation and Recycling, 204*, Article 107472.

[8]   Paes, M. X. et al. (2024). Waste Management Intervention to Boost Circular Economy and Mitigate Climate Change in Cities of Developing Countries: The Case of Brazil. *Habitat International, 143*, Article 102990.

[9]   Russian Public Opinion Research Center. (2024, February 6). *Ecological Situation in Russia: Monitoring.* https://wciom.ru/analytical-reviews/analiticheskiiobzor/ehkologicheskaja-situacija-v-rossii-monitoring-2. (In Russian).

considered climate change adaptation or mitigation and are not included in official policies at the federal and regional levels. Therefore, this article aims to evaluate the green waste practices of nongovernmental organizations and citizens and to describe the possibilities of incorporating these practices into climate mitigation and adaptation policies.

To evaluate the activities of nongovernmental organizations in terms of their contribution into climate adaptation and mitigation policies, we focus on two nongovernmental organizations, "Krugovorot" and "RazDel'nyi Sbor." The organizations carry out green practices, including waste management and pollution prevention. They operate in two cities: St. Petersburg (5.6 million inhabitants) and Tyumen (850 thousand inhabitants). The population of these cities has a high level of living; the average monthly salary in St. Petersburg amounted to 91,886 rubles and in Tyumen – 90,705 rubles in 2023. Both cities are regional centers; St. Petersburg is located in the northwest of the country, and Tyumen is in Western Siberia.

Founded by eco-activists, these organizations have been involved in separate waste collection for more than 10 years. The environmental nongovernmental organization "RazDel'nyi Sbor" which means "Separate waste collection" started separate waste collection in St. Petersburg in 2011. Currently, the organization aims to implement separate waste collection to develop responsible production and consumption and to improve the environment and the quality of human life.[10] The nongovernmental organization "Nol' otkhodov v Tiumeni. Krugovorot" which means "Zero waste in Tyumen. Circulation" was founded in Tyumen in 2014 when a group of young people came together to collect recyclable materials in a mobile station and transport them for recycling. Since 2019, a permanent waste collection station has been operating. In general, "Krugovorot" aims to develop green practices in Tyumen.[11] Involving volunteers and thousands of people in their activities, "RazDel'nyi Sbor" and "Krugovorot" are the examples of successful grassroot initiatives related to waste management. Scientists emphasize the public importance and influence of these organizations which manifest that grassroot initiatives are a special feature of the Russia's waste management.[12]

In order to develop recommendations for state climate policy and law, it is beneficial to consider a wider range of methods, not just legal ones. Legal methods and research

---

[10]   Mission of the Movement (2024). Ecological Movement "RazDel'nyi Sbor." https://rsbor.ru/about/mission/. (In Russian).

[11]   About Us (2024). Ecological Movement "Krugovorot. Zero Waste in Tyumen." https://zerowastetmn.ru/about/. (In Russian).

[12]   Shabanova, M. (2024). Unnecessary Items, Waste Issue and Solidarity Practices Among Russian Consumers. *Journal of Economic Sociology, 25*(2), 11–42. (In Russian); Chalganova, A. (2016). Sustainable Development and the Problem of Municipal Solid Waste Management in Russia. *Perspectives of Science, 12*(87), 135–139. (In Russian)

often fail to evaluate social relations that go beyond the law. It is therefore necessary to utilize and benefit from complicated methodologies, one of those is automated big data analysis which is capable to prove the relevance of social practices and incorporate them into state climate policy. In this study, we use modern language models pretrained on large collections of texts and then fine-tuned on the target dataset. Pretraining allows for a deeper understanding of text semantics compared to classical text analysis algorithms, while fine-tuning on the target dataset enables the identification of patterns within the texts related to environmental nongovernmental organizations. The information obtained provides knowledge about social processes to formulate justified recommendations for climate policy and law.

To evaluate these organizations' green waste practices from a climate mitigation or adaptation policy perspective, we focused on nine green practices, such as waste sorting, studying the product labeling, waste recycling, and signing petitions, exchanging, refusing purchases, sharing, repairing, and participating in actions to promote responsible consumption. Practices aimed at reducing greenhouse gas emissions or their sequestration are determined as mitigation ones, while adaptation is perceived as practices aimed at adapting to the negative effects of climate change or utilizing the positive effects. An illustrative example of mitigation practices is waste recycling, which reduces the carbon footprint of products and greenhouse gas emissions from landfills, while an example of adaptive practices can be sharing, which helps people meet their needs in the condition of declining production.

To examine the potential of green practices for climate policy, we studied the prevalence of each practice in the activities of "Krugovorot" and "RazDel'nyi Sbor" and the subscribers' interest in these practices by using information from the online communities in the Russian social media (VK). Communities in VK are the main platform for disseminating information about activities and attracting subscribers.[13] Online communities allow accumulating and broadcasting the experience of separate waste collection to many people; the total number of subscribers in both communities is almost 100,000 people. Besides, through extensive eco-enlightenment content, online communities are becoming important sites for greening society[14] and engaging new participants in offline activities.[15] Posts and subscribers' involvement provide important social information,[16] which can be used

[13] Shalunova, E. (2013). "RazDel'nyi Sbor" – Mission Possible. *Solid Household Waste, 12*(90), 52–55; Pupkova, Y., & Grabovskaya, E. (2019). Eco-Ducational Potential of Social Media (the Case Study of Online Communications of the Association "Separate Waste Collection"). *Information and Education: Boundaries of Communications*, *19*(11), 156–158. (In Russian).

[14] Pupkova & Grabovskaya, 2019.

[15] Tsepilova, O., & Golbraih, V. (2020). Environmental Activism: Resource Mobilisation for "Garbage" Protests in Russia in 2018–2020. *Journal of Sociology and Social Anthropology, 23*(4), 136–162. (In Russian).

[16] Zakharova, O., & Glazkova, A. (2024). GreenRu: A Russian Dataset for Detecting Mentions of Green Practices in Social Media Posts. *Applied Sciences, 14*(11), 1–17; Frolov, A., & Agurova, A. (2019). Index Analy-

to monitor the environmental activities promote the implementation of climate policies.[17]

Additionally, we assessed the prevalence of mentions of green practices by evaluating the subscribers' interest in these posts. For this purpose, the posts were classified using a language model fine-tuned on a dataset for detecting mentions of green practices. For classified posts, we calculated the engagement index of social media subscribers. It was calculated as the ratio of users' activity in relation to this post (through the number of likes, reposts, and comments) to the number of views of this post.

1. Climate Regulatory Framework
and Grassroots Waste Management Initiatives

To improve waste management and solve some environmental problems, the government of the Russian Federation implemented a waste management reform in 2019. The activities of collection, transportation, treatment, recycling, disposal, neutralization, and burial of solid municipal waste were entrusted to organizations that were named regional operators. Thus, in 2019 Tyumen Ecological Association was established as a regional operator for municipal solid waste management in Tyumen region[18]. In 2021, Nevsky Ecological Operator was granted the status of a regional operator for solid municipal waste management in St. Petersburg.[19] Consequently, both regional operators started their activities on the territory where some companies and nongovernmental organizations had been involved in separate waste collection for many years.[20] However, these two regional operators did not include the existing practices related to separate waste collection in their planned activities. Moreover, the activities of these regional operators became an obstacle for other organizations dealing with separate waste collection and processing in St. Petersburg and Tyumen. Instead of separate waste collection on waste-generated sites, the regional operators were planning to sort waste at specialized plants. So far, separate waste collection has only been sporadically and fragmentarily present in the activities of these regional operators.

---

sis of Active Citizenship in Social Networks. *Bulletin of Irkutsk State University. Geoarchaeology, Ethnology, and Anthropology Series*, *29*, 28–43. (In Russian).

[17]   Shchekotin, E., Dunaeva, D., Basina, P., & Vakhrameev, P. (2023). Digital Footprints in Ecology: Empirical Research. *Virtual Communication & Social Networks*, *2*(4), 255–263. (In Russian).

[18]   Tyumen Ecological Association. https://teo.ecotko.ru/

[19]   Nevsky Ecological Operator. https://spb-neo.ru/

[20]   Institute of Design, Ecology and Hygiene. (2021). *Unified Concept of Solid Municipal Waste (SMW) Management in the Territory of St. Petersburg and Leningrad Region (with the Possibility of Waste Stream Separation)*. https://spb-neo.ru/upload/docs/Единая%20концепция%20текст_приложения_20.02.2022.pdf. (In Russian).

It is worth emphasizing that nongovernmental organizations in the field of waste management organized separate waste collection long before the 2019 government waste management reform. For example, the environmental organization "RazDel'nyi Sbor" started separate waste collection in St. Petersburg in November 2011. In 2013, more than a thousand people participated in one campaign compared to 40,900 participants in 2023. By 2017, campaigns had been held in 25 different locations in the city.[21] Volunteers collected waste paper, glass containers, plastic, multilayer tetrapack cartons, and CDs from local citizens once a month. The list of accepted types of waste varied depending on the rules of public services, legislative changes, and interaction with entrepreneurs. "RazDel'nyi Sbor" cooperates with different organizations that transport and recycle waste.[22] To the present day, the organization considers separate waste collection mandatory for encouraging a responsible production and consumption society and improving the environment and the quality of life. "RazDel'nyi Sbor" promotes the 3R principles (reduce, reuse, recycle) and conducts many enlightening events focusing on waste prevention. For example, in 2023, 26,494 people participated in such events.[23] Apart from separate waste collection and environmental related events, the environmental organization "RazDel'nyi Sbor" is engaged in legislative initiatives in the sphere of waste management, developing volunteerism, greening business, etc.

Another environmental organization "Krugovorot" was founded in Tyumen in 2014. Its volunteers started the Eco-Mobile project, driving around several locations in the city and picking up recyclable materials. In 2019, a waste collection station was established and positioned as a training center for waste management. In 2022, "Krugovorot" had 35 volunteers helping 14,000 people sort waste for recycling.[24] "Krugovorot"'s activities are based on the Zero Waste concept aimed at minimizing waste generation. Therefore, this organization encourages reducing consumption by exchanging, refusing purchases, sharing, repairing, and reusing. For this purpose, the volunteers deliver enlightenment lectures, arrange sharing practices, and hold many different events in residential areas, schools, and various public places of the city.

The activities of "RazDel'nyi Sbor" and "Krugovorot" have been previously examined as flagships of grassroots environmental initiatives.[25] These organizations help to

---

[21]   Shalunova, 2013; Guseva & Polishchuk, 2017; Ecological Movement "RazDel'nyi Sbor." (2023). Ecological Movement "RazDel'nyi Sbor." (2023). *Ecological Movement "RazDel'nyi Sbor": Annual Report 2023*. https://rsbor.ru/assets/templates/rsbor/docs/rds_docs/reports/Godovoy_otchet_2023.pdf. (In Russian).

[22]   Guseva & Polishchuk, 2017.

[23]   Ecological Movement "RazDel'nyi Sbor," 2023.

[24]   About Us, 2024.

[25]   Zatolokin, A., & Petrov, Y. (2023). "Tire Trap" in the Urban Improvement of Tyumen: Environmental, Social and Economic Problems. *Waste and Resources*, *10*(4), 1–9. (In Russian); Guseva & Polishchuk, 2017; Pupysheva, I. N., Zakharova, O. V., & Kuznetsova, N. (2023). Varieties of the Discourse about Collection and Processing of Recyclable Materials: Between Pursuit of Gain and Saving the World. *Sotsiologicheskie issledovaniya*, *3*, 53–65. (In Russian).

solve important problems: the growth of landfill space, increasing waste volumes, plastic pollution, and the declining quality of various waste types due to their mixing with food waste.[26] "RazDel'nyi Sbor" and "Krugovorot" are an important platform for communicating with the citizens and helping to maintain an environmentally friendly way of life.[27] Researchers also highlight the contribution of these organizations to the development of separate collection infrastructure, creating the possibility to dispose of rare types of waste and, in general, different types of waste in one location.[28] The organizations cooperate not only with the public and other nongovernmental organizations, but also with the government.[29] Additionally, the activists of "RazDel'nyi Sbor" and "Krugovorot" take part in various seminars, online conferences, festivals, panel discussions, and media interviews promoting an environmentally friendly lifestyle.[30] However, the environmental activities are not considered from the perspective of climate policy thought they can be a contribution to the adaptation to climate change or to mitigation of anthropogenic impact on the climate. To justify the involvement of nongovernmental organizations into the climate policy in the Russian Federation we assessed the prevalence of mentions of nine green practices of these organizations in their online posts; second, we studied subscribers' interest in posts mentioning green practices and calculated the engagement index; third, we identified the features of subscribers' interest in green practices in two Russian cities.

2. Big-Data Analysis
as a Method to Justify State Climate Policy

2.1. Data

For this study, the VK API[31] was used to collect the posts from the "Krugovorot" and "RazDel'nyi Sbor" VKontakte communities published from 2014 to 2023. Only the posts containing textual information were selected. The data statistics and dynamics of posts and user activity including comments, likes, and reposts are presented in Table 1 and Figure 1, 176 respectively.

---

[26]   Risto, E. (2020). Waste Management System in Saint Petersburg: The Selection of the Optimal Waste. *Current Scientific Research in the Modern World, 9-2*(65), 17–20. (In Russian).

[27]   Shalunova, 2013.

[28]   Golovneva, A., & Chernysheva, L. (2017). Plastic, Bicycles and Urban Citizenships: Two Cases of Infra-structural Reorganization in St. Petersburg. *Journal of Sociology and Social Anthropology*, *20*(3), 7–31. (In Russian).

[29]   Guseva & Polishchuk, 2017.

[30]   Shalunova, 2013.

[31]   API | VK for developers. https://dev.vk.com/en/reference

Table 1
The Data Statistics

Characteristic	Krugovorot	RazDel'nyi Sbor
Number of posts from 2014 to 2023	1,596	7,169
Avg post length (symbols)	890.94±811.91	986.79±932.95
Number of subscribers (08-28-2024)	9,061	88,951

2.2. Evaluation of the Prevalence of Environmental Waste Practices

Since we analyzed a large number of posts, we used machine learning methods to search for mentions of green waste practices. For each green waste practice, a language model was fine-tuned for a binary text classification problem. The GreenRu dataset[32] was used for fine-tuning. GreenRu is the first dataset for detecting mentions of green practices in Russian social media posts. It contains 1,326 posts collected in Russian online communities. Each post has a sentence-level markup, the total number of mentions of green waste practices in GreenRu is 3,765. GreenRu covers nine types of green waste practices described in:[33] 1) waste sorting (P1), separating waste by its type; 2) studying the product labeling (P2), identifying product packaging as a type of waste; 3) waste recycling (P3), converting waste materials into reusable materials for further use in the production of something; 4) signing petitions (P4), signing documents to influence the authorities; 5) refusing purchases (P5), consciously choosing not to buy certain products or services that have a negative environmental impact, thereby reducing consumption and environmental footprint; 6) exchanging (P6), giving an unnecessary item or service to receive the desired item or service; 7) sharing (P7), using one thing by different people for a fee or free of charge; 8) participating in actions to promote responsible consumption (P8), participating in any events (workshops, festivals, lessons) aimed at popularizing the idea of reducing consumption; 9) repairing (P9), restoring consumer properties of things as an alternative to throwing them away.

In this study, we used RuBERT-base-cased,[34] a Russian-language adaptation of the BERT model.[35] To create validation sets, 100 random posts for each online community ("Krugovorot" and "RazDel'nyi Sbor") were selected and annotated by an expert on green practices from the University of Tyumen, Russia. Thus, we first fine-tuned

---

[32] Zakharova & Glazkova, 2024.

[33] Zakharova, O. V., Glazkova, A. V., Pupysheva, I. N., & Kuznetsova, N. V. (2022). The Importance of Green Practices to Reduce Consumption. *Changing Societies & Personalities, 6*(4), 884–905.

[34] RuBERT. (n.d.). Hugging Face. https://huggingface.co/DeepPavlov/rubert-base-cased

[35] Kuratov, Y., & Arkhipov, M. (2019). Adaptation of Deep Bidirectional Multilingual Transformers for Russian Language. In *Computational Linguistics and Intelligent Technologies: Proceedings of the International Conference "Dialogue": Issue 18* (pp. 333–339). V.V. Vinogradov Russian Language Institute of the Russian Academy of Sciences. (In Russian). https://ruslang.ru/doc/stoynova/Khomchenkova&Pleshak&Stoynova-2019-NonStandRussianCorpus.pdf

ten models for each green waste practice using the input length of 256 tokens, the learning rate of 4e-5, the cross-entropy loss function, and the AdamW optimizer. The number of training epochs was randomly selected within the range from one to ten. The model that showed the best performance (F1-score) on the validation set for each community was used to annotate mentions of green practices in the collected posts from this community. The average F1-score across all green waste practices on the validation set was 64.05% for "RazDel'nyi Sbor" and 71% for "Krugovorot."

2.3. Engagement Index

To determine subscriber involvement in the discussion of posts, we used the engagement index based on the article of Frolov and Agurova.[36] In this work, the engagement index was utilized for analyzing subscribers' involvement in discussions about waste disposal in Russia. The engagement index E' proposed in the article *Adaptation of Deep Bidirectional Multilingual Transformers for Russian Language*[37] evaluates the number of comments, likes, and reposts for each post relative to the total number of subscribers in the community:

$$E'_i = \frac{likes_i \times a + comments_i \times b + reposts_i \times c}{subscribers} \times 100\%, \quad (1)$$

where a, b, and c represent weight coefficients for likes, comments, and reposts respectively, $likes_i$, $comments_i$, $reposts_i$ are the number of likes, comments, and reposts for the i post, $subscribers$ is the number of subscribers in the community. The weight coefficients a, b, and c were determined in[38] as 0.26, 0.35, and 0.39 respectively based on a survey of experts.

The mentioned study was conducted on short-term data from 2018 to 2019. However, our study considers a ten-year time frame. Over ten years, the number of subscribers can change significantly, and we do not have retrospective data on the number of subscribers. Thus, using the number of subscribers to calculate subscribers' involvement does not seem appropriate. Therefore, we adapted the engagement index E for analyzing subscribers' involvement using long-term data. For this purpose, we propose using the number of views of a specific post instead of the number of subscribers. The view counter for posts became available on the social network VKontakte on January 1, 2017. Therefore, data on views is unavailable for posts from 2014–2016. For posts from this period, we predicted the number of views based on available data on likes, comments, reposts, and the year of publication.

---

[36]   Frolov & Agurova, 2019.

[37]   *Id.*

[38]   *Id.*

To accomplish this, we trained a linear regression model implemented using Scikit-learn.[39] The adapted engagement index *E* takes the form:

$$E_i = \frac{likes_i \times a + comments_i \times b + reposts_i \times c}{views_i} \times 100\%,$$

(2)

where *views_i* represents the number of views for the *i* post. Thus, to assess subscribers' involvement for a specific post, the number of likes, comments, and reposts, multiplied by the corresponding coefficients, is used relative to the number of views of the post.

3. Prospects for Incorporating Grassroots Waste Management Initiatives into State Climate Policy

The study showed the dynamics of activity in online communities of nongovernmental organizations "RazDel'nyi Sbor" and "Krugovorot" over 10 years, in terms of both content creators and subscribers (Figure 1, a, b). For example, we can see the maximum number of posts in "Krugovorot" in 2017 when "Krugovorot"'s activities included organizing truck routes to collect recyclable materials from residents in various locations in the city (Figure 1, a). Therefore, some of the posts were functionally providing relevant information on the planned actions. In addition, the increase in the number of posts in 2017 may be related to the construction of a waste sorting plant, which was actively discussed in the community, and the launch of "Krugovorot" projects in other cities of the region. The active work of community members and other participants on separate waste collection resulted in Tyumen being among the top 20 cities in the ranking of separate waste collection availability in 2017. The lowest number of posts in the "Krugovorot" community was in 2020, when separate waste collection was suspended due to the lockdown. During the same period, the subscribers' activity was at its lowest too, as the lockdown interrupted its growth and then quickly recovered after the COVID-19 pandemic. The increase in the subscribers' activity is due to the growth in the number of subscribers, for example, in 2017 the number of subscribers grew from two thousand people to five thousand.

---

[39] Pedregosa, F., et al. (2011). Scikit-Learn: Machine Learning in Python. *Journal of Machine Learning Research, 12*, 2825–2830.

a) Krugovorot   b) RazDel'nyi Sbor
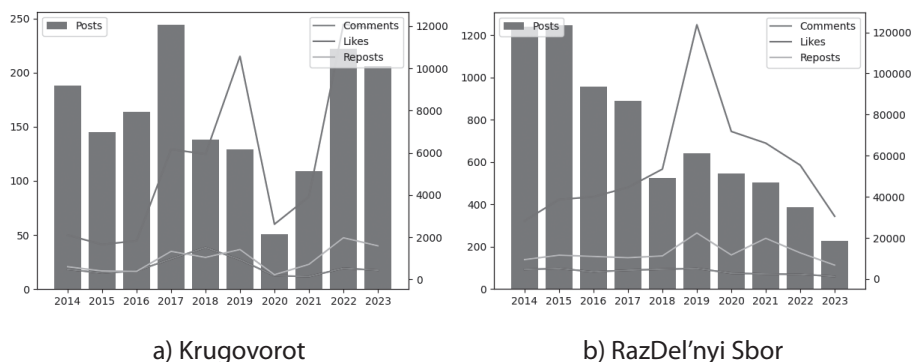
In the online community of "RazDel'nyi Sbor," the highest number of posts was in 2014 and 2015 (Figure 1, b). Until now, the number of posts started to decrease. In addition to functional posts about the venue, time, and rules for accepting recyclable materials, in 2014 the community discussed the construction of an incineration plant, which caused a negative reaction from both eco-activists and the community subscribers. Additionally, the posts contained information about project teams that worked in different city locations. The posts about special environmental events and about new locations for receiving various types of waste were the most welcomed by the subscribers during that period. The peak of "RazDel'nyi Sbor" subscribers' activity was in 2019, when much support was given to posts about protest actions and petitions related to the construction of new landfills, new legislative initiatives, and protests against non-environmental actions, such as the mass launch of balloons on holidays (Figure 1, b).

The study showed which practices were mentioned in posts more often and visualized the dynamics of these mentions (Figure 2, a, b). For "Krugovorot," the practice of separate waste collection was mentioned most often (P1), the posts included announcements about waste collection times and locations, schedule changes, and information about different types of waste such as plastic lids, biodegradable plastic, tin cans, etc. (Figure 2, a). The second most frequently mentioned practice was participation in actions to promote responsible consumption (P8), since the organization employs volunteers, the posts contained calls to join the team to help during the actions. The posts also included requests for financial support, calls for cooperation with each other, and invitations to events. For example, the Eco-Neighbor campaign announced calls to help neighbors who did not have a car by taking their waste to a permanent waste collection station. During the COVID-19 pandemic, participation in actions to promote sustainable consumption was mentioned even more often than separate

collection, because a permanent waste collection station was not functioning due to the lockdown, and actions could be carried out online. Sharing (P7) and other ways to reduce consumption (P5) were mentioned frequently in "Krugovorot" posts because they are important practices in the Zero Waste concept promoted in this community. For example, eco-activists proposed a solution to the problem of leftover food by organizing food sharing online community. Another example, eco-activists organized enlightening lectures on sustainable fashion, which included tips on minimizing the clothing used. During the pandemic, mentions of these practices declined strongly and did not return to previous levels until 2023. In contrast, the mention of recycling practices (P3) became more frequent in 2021–2023. Posts mentioning this practice included a description of the operation of a waste sorting plant located near the city, as well as a description of how the "Krugovorot"'s partners used sorted waste in their production. Such posts emphasized the importance of waste sorting and received a positive response from subscribers.

Figure 2

The Distribution of the Number of Posts That Mention Green Waste Practices

a) Krugovorot   b) RazDel'nyi Sbor
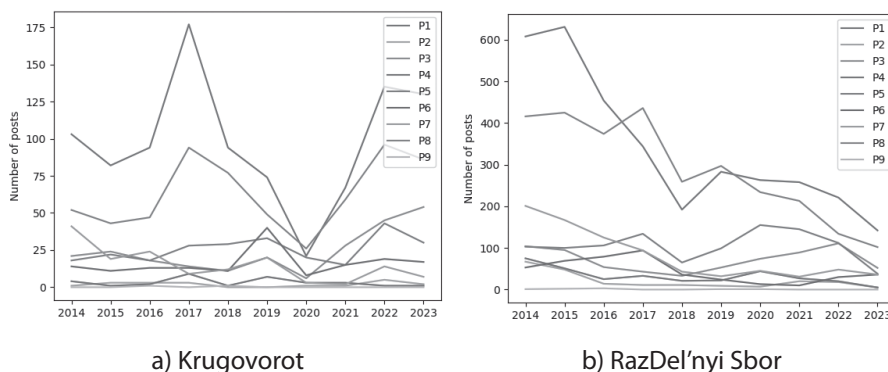
Regarding "RazDel'nyi Sbor," mentions of separate waste collection practices (P1) and actions to promote responsible consumption (P8) tended to be the most common (Figure 2, b). For almost three years, 2016–2019, actions promoting responsible consumption were mentioned more often than actions related to the organization of separate waste collection, because "RazDel'nyi Sbor" focused on waste prevention and enlightenment activities and posted about them frequently. For example, eco-activists of "RazDel'nyi Sbor" participated in various festivals, discussion platforms, rallies on environmental issues. For the same reason, refusing purchases (P5) and sharing (P7) were also mentioned very often in community posts. For example, "RazDel'nyi Sbor" organized a free distribution of jam jars to anyone who needed one so that the jars could be used over and over again. We have already mentioned the

high protest activity of the community, which is also confirmed by the high frequency of mentioning the practice of signing petitions (P4). The posts creators often criticized the actions of authorities, organizers of events and manufacturers of goods, and subscribers were invited to join in signing petitions or to write a complaint.

Our research also allowed studying the dynamics of subscribers' interest in posts published in "RazDel'nyi Sbor" and "Krugovorot" communities by analyzing likes, reposts, and comments (Figure 1, a, b). Subscribers' interest in "Krugovorot"'s activities peaked in 2023, especially in the number of likes and reposts (Figure 1, a). This can be explained by both a twofold increase in the number of subscribers from 2017 to 2023 and the growing relevance of the climate and environmental agenda in Russian society. Subscribers demonstrated solidarity with the content of the post through likes and tried to share important information through reposts.[40] The number of comments in "Krugovorot" community decreased in 2020 and has not changed significantly since that period. Since comments in the community most often represented inquiries about the actions, the decrease in their number was due to the stabilization of the activities of the environmental organization because the permanent waste collection station had working hours and a list of types of accepted waste. In addition, registering for events through comments used to be spread in the community, later it was replaced by online registration. Often comments informed about the financial support provided. Additionally, comments contained congratulations, thanks, criticism, words of encouragement, and sharing personal experiences.

In "RazDel'nyi Sbor" community, the maximum subscribers' activity was in 2019, which can be explained by mass protests against the construction of a new landfill in a neighboring region, attempts to weaken environmental legislation, and non-environmental practices of organizers of festive events (Figure 1, b). Thus, strong approval of subscribers in 2019 was given to posts with calls to participate in protest events. However, the post containing relevant environmental information about micro plastics in food products gained the highest number of likes in 2019. This information was shared by more than a quarter of those who liked it. In the comments to this post, people expressed emotions and shared additional information. Subscribers most often shared the post about the questionnaire on the readiness to join separate waste collection.

We also evaluated subscribers' interest toward green practices by analyzing likes, reposts and comments on posts that mention these practices (Tables 2, 3). The number of reposts and likes of posts mentioning signing petitions practices (P4) was particularly high in "Krugovorot," with subscribers actively discussing and joining proposed petitions (Table 2). For example, in Tyumen, the implementation of the waste management reform led to the closure of small waste recycling businesses

---

[40]   Frolov & Agurova, 2019.

and the destruction of the separate waste collection infrastructure that had already existed in Tyumen residential areas. Tyumen residents criticized the reform that caused the increase in utility bills. They participated in signing a petition addressed to the authorities to develop separate waste collection near houses and reduce payments for utilities. Subscribers also frequently shared information about waste labeling (P2), new actions for sharing things (P6), and requests for community help (P8). Posts mentioning recycling practices (P3), exchanging (P6), and enlightenment events (P8) received more likes than posts mentioning sharing (P7) or repairing (P9) practices. The average number of comments was one comment per post. Subscribers commented more on the posts mentioning sorting (P1), recycling (P3), labeling (P2), and signing petitions (P4). In general, the engagement index for the practices mentioned in the "Krugovorot" community showed that the practices of studying the product labeling (P2) and signing petitions (P4) were of the greatest interest to subscribers (Figure 3).

Figure 3

The Values of Engagement Index per Green Waste Practice for "Krugovorot" and "RazDel'nyi Sbor"
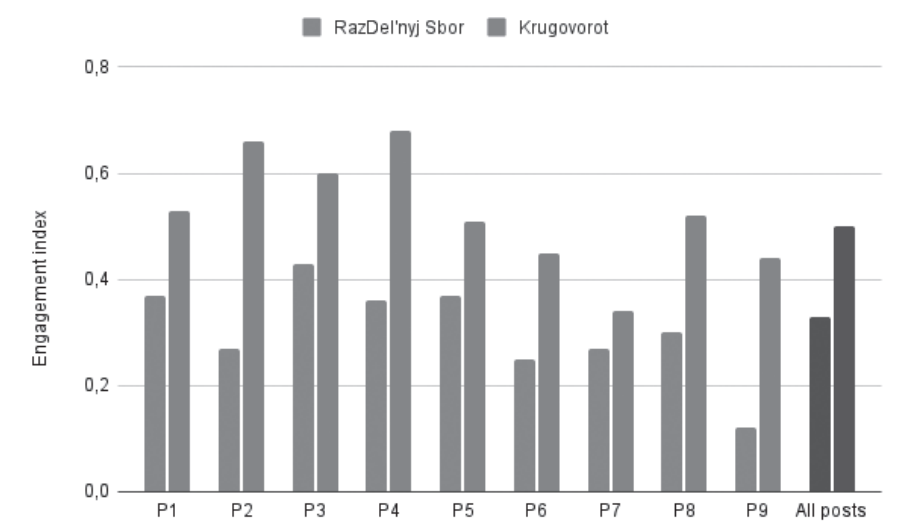
Table 2

The Indicators of Users' Activity in the "Krugovorot" Community

Practice	Likes		Comments		Reposts		*E*	
	Avg	Median	Avg	Median	Avg	Median	Avg	Median
P1	39.86	23	4.81	2	6.29	3	0.53	0.5
P2	51.47	29	5.21	2	10.16	6	0.66	0.53
P3	58.77	39	3.59	2	9.17	4	0.6	0.6
P4	92.28	62.5	4.28	2.5	17.84	8	0.68	0.73
P5	39.97	30	3.18	1	6.87	3	0.51	0.48
P6	36.4	29	2.81	0	6.71	3	0.45	0.45
P7	21.11	11	1.46	0	5.26	2	0.34	0.3
P8	38.08	28	4.13	1	5.79	3	0.52	0.49
P9	17	17	1	1	1.5	1.5	0.44	0.44
All posts	36.85	22	3.71	1	6.1	3	0.5	0.47

Regarding "RazDel'nyi Sbor," on average, posts mentioning recycling (P3) and refusing purchases (P5) received maximum approval in the community (Table 3). For example, posts dedicated to Global Recycling Day were very popular in the community. Another example of popular posts was tips on how not to buy unnecessary items or how to replace disposable plastic packaging with reusable packaging. The practice of signing petitions (P4) was third place in number of likes. Subscribers' comments most often included information related to waste recycling (P3), actions on separate waste collection (P1), and waste labeling (P2). For example, the construction of an incineration plant was actively discussed: the government proposed incineration as a way to convert waste into heat energy, but eco-activists insisted that waste should be involved in the production of products, not incinerated. Subscribers also asked many questions to clarify the list of accepted waste and expressed their gratitude to the volunteers who worked on the actions. Subscribers to "RazDel'nyi Sbor" community were most likely to share information about recycling practices (P3), separate waste collection (P1), and petition signing (P4). Reposts most often referred to the information related to protest actions, which proves the strong influence of the community on the public life in St. Petersburg and neighboring regions and political engagement of the population. The engagement index of the "RazDel'nyi Sbor" community subscribers was higher in relation to mentions of recycling practices (P3), signing petitions (P4), and refusing purchases (P5) (Figure 3).

Table 3

The Indicators of Users' Activity in the "RazDel'nyi Sbor" Community

Practice	Likes		Comments		Reposts		E	
	Avg	Median	Avg	Median	Avg	Median	Avg	Median
P1	87.36	49	5.92	3	21.74	10	0.37	0.28
P2	73.2	13	6.31	3.5	16.11	1	0.27	0.11
P3	125	90	6.4	4	27.88	15	0.43	0.41
P4	96.02	48	6.28	2	24.66	8	0.36	0.27
P5	98.44	55	4.87	2	21.06	9	0.37	0.3
P6	52.25	28.5	2.04	0	12.87	6	0.25	0.18
P7	61.64	24.5	4.35	2	15.11	6	0.27	0.17
P8	64.74	37	3.86	1	12.84	6	0.3	0.21
P9	27.5	21	0.88	0	3.75	1.5	0.12	0.07
All posts	77.06	40	5.07	2	17.71	7	0.33	0.24

We identified the top 20 posts with the highest engagement index in each online community. In "Krugovorot" community, the greatest interest was aroused by the posts about resuming the collection of popular types of waste, about "Krugovorot" obtaining legal status, bright dates in the history of the organization, collection points of hazardous waste. The message about signing a petition to organize separate collection in the residential areas was found only once in the top 20. However, in "RazDel'nyi Sbor" community 8 out of 20 most interesting posts for subscribers were of protest issue. Thus, posts about the refusal of balloons at city events aroused the greatest interest. In addition, subscribers were interested in posts about waste collection actions, about the collection of rare types of waste, for example, New Year trees.

The study found that environmental organizations "RazDel'nyi Sbor" and "Krugovorot" arranged activities that can a crucial part of climate change adaptation or mitigation (Figure 4). For example, the activities of these organizations helped to build chains in the logic of the circular economy, such as studying the labeling of packaging of goods, sorting waste, using waste in the production of new things, signing petitions to improve such chains.[41] Through such chains, the carbon footprint of waste and the production of new things is reduced, which can be used as part of measures to reduce human impact on climate.[42] Eco-activists have much experience in organizing separate collection in apartments and residential areas, interaction with waste transporters and recyclers, which will allow using their experience to replicate

---

[41]   Hobson, K. (2020). "Small Stories of Closing Loops": Social Circularity and the Everyday Circular Economy. *Climatic Change, 163*(1), 99–116.

[42]   Creutzig et al., 2022.

the most efficient chains in the logic of circular economy.[43] Moreover, eco-activists favor recycling methods that reduce greenhouse gas emissions without exacerbating other environmental problems.[44] For instance, eco-activists of "RazDel'nyi Sbor" opposed the construction of an incineration plant as an alternative to waste processing, because they believed that such a plant would not solve the problem of waste, but it would only increase the problems of environmental pollution.

Figure 4

The Number of Posts That Mention Green Waste Practices

a) Krugovorot   b) RazDel'nyi Sbor
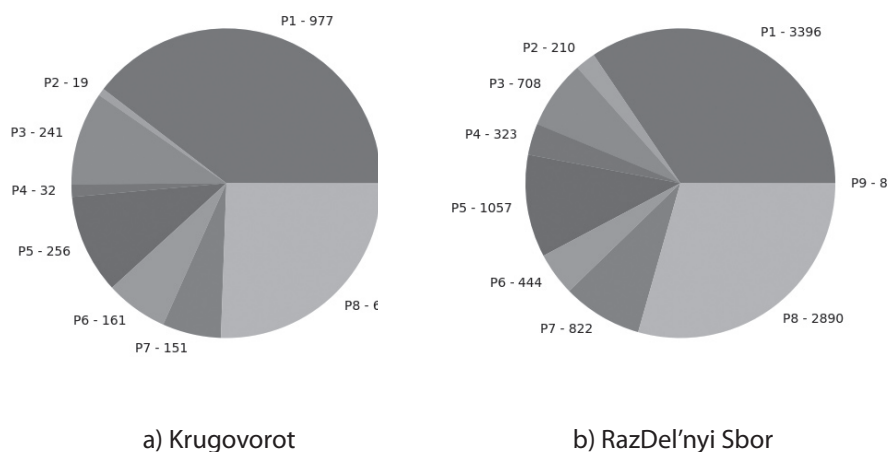
In turn, weather hazards and cataclysms, as well as reduced resources and production, will require behavioral changes as part of adaptation activities.[45] Therefore, practices such as sharing, exchange, and repairing can help people adapt to new conditions and reduce consumption without reducing the quality of life.[46] Sharing, for example, allows people to use the same things for longer time.[47] In addition, these environmental organizations lead campaigns to promote behavioral

---

[43]   Shabanova, 2024.

[44]   Verplanken, B., & Whitmarsh, L. (2021). Habit and Climate Change. *Current Opinion in Behavioral Sciences, 42*, 42–46.

[45]   Dubois, G., et al. (2019). It Starts at Home? Climate Policies Targeting Household Consumption and Behavioral Decisions Are Key to Low-Carbon Futures. *Energy Research & Social Science, 52*, 144–158; Creutzig et al., 2022.

[46]   Raworth, K. (2017). *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. Chelsea Green.

[47]   Hobson, K., & Lynch, N. (2016). Diversifying and De-growing the Circular Economy: Radical Social Transformation in a Resource-Scarce World. *Futures, 82*, 15–25.

change and waste prevention, have successful cases of engaging people in new practices, and authorities and regional solid waste management operators can scale their experience (Figure 4). Thus, on the one hand, green waste practices that improve waste management can be expanded and supported within the framework of climate mitigation policies and strategic documents.[48] On the other hand, green organizations have considerable experience in promoting practices that prevent waste generation and meet the needs of people in the context of decreasing production of things, which can be supported within the framework of adaptation activities.[49]

The organizations "RazDel'nyi Sbor" and "Krugovorot" have existed for a long time and have proven their ability to interact with various actors of environmental change. They have legal status, which makes it possible to legitimize interaction and cooperation with them. Therefore, cooperation with these organizations can be seen as an important way of bottom-up management and involvement of grassroots initiatives in climate policy implementation.[50]

It should be emphasized that these organizations need financial support.[51] Both organizations accept waste free of charge and give it to recyclers for a fee, but the market price of waste is so low that it does not cover even half of the organizations' expenses. State financial support in the form of grants is rarely received by these organizations and does not ensure their stable operation. Both organizations exist on donations from subscribers and entrepreneurs. Both organizations are constantly under the threat of cessation of activities and complete closure. It is a paradoxical situation: a socially significant activity can stop due to the lack of funding at the very time when it can help to implement strategic initiatives of the state.[52] Integrating these and other similar organizations as implementers in government programs will allow them to receive stable funding and fulfill their potential to achieve climate goals.[53]

---

[48]   Guseva & Polishchuk, 2017.

[49]   Kasianova, A., Frolenok, V., & Chekrygin, M. (2020). The Change of Everyday Habits of People According to Current Ecological Situation. *Business Education in the Knowledge Economy*, *2*(16), 65–68. (In Russian).

[50]   Creutzig et al., 2022.

[51]   Guseva & Polishchuk, 2017.

[52]   Schmid, B. (2021). Hybrid Infrastructures: The Role of Strategy and Compromise in Grassroot Governance. *Environmental Policy and Governance, 31*(3), 199–210.

[53]   Litvintsev, D., Abramova, N., & Romanov, D. (2023). Separate Waste Collection: Institutional Problems of Developing Pro-Ecological Practices in Everyday Life. *Monitoring of Public Opinion: Economic and Social Changes*, *3*(175), 169–185. (In Russian); Verplanken & Whitmarsh, 2021; Concari, A., Kok, G., & Martens, P. (2022). Recycling Behaviour: Mapping Knowledge Domain Through Bibliometrics and Text Mining. *Journal of Environmental Management, 303*, Article 114160.

Conclusion

The study demonstrates that environmental nongovernmental organizations have been active for 10 years, engaging hundreds of people in green practices that help reduce anthropogenic climate impacts or adapt to climate change. These green practices can be included in government policy documents as mitigation activities, such as the often-mentioned practices of separate waste collection, recycling, or as adaptation activities, such as promoting responsible consumption or refusing purchases.

This study has justified that environmental nongovernmental organizations "RazDel'nyi Sbor" and "Krugovorot" carry out complex activities related to waste, they are involved not only in waste management, but also in waste prevention, which can be used to implement climate policy. The activities of these green organizations attract wide public interest, subscribers of the online communities of these organizations are actively involved in offline activities. Subscribers are aware of ways to reduce consumption and manage waste responsibly. Participation in separate waste collection, exchanges, sharing, etc. has become a part of their daily life and they can share their experience in the communities, especially with the governmental support.

However, ignoring grassroots initiatives can lead not only to a decrease in the effectiveness of climate policy, but also to conflicts in society. The study has shown that the maximum value of the engagement index is associated with topics negatively perceived by society, people's protest can be caused both by the actions of the government and non-environmental actions of various organizations.

Our recommendations for governmental policies are as follows:

1. It is necessary to use the valuable experience of environmental nongovernmental organizations for implementation of behavioral changes, involve them in activities within the framework of mitigation and adaptation policies.

2. The activities of environmental public organizations should be financially supported and the budget money allocated for the implementation of climate policy.

Evaluation of the dynamics of environmental nongovernmental organizations' activities allows us to determine the periods of maximum and minimum activity during 10 years. Further research is required to identify internal and external factors affecting the activities of these organizations in the periods of maximum and minimum activity, considering them as opportunities and threats. In addition, evaluation of the dynamics of mentions of green waste practices provides an opportunity to analyze trends in the activities of environmental communities and to propose measures to support certain green waste practices.

The study has manifested that big data analysis can be used to improve legislation and to develop state climate policy.

The main limitations of the research are related to the fact that we have studied the activities of only two environmental nongovernmental organizations that are related to waste management. Further study of various environmental organizations

is required to establish common patterns of their activities and broad involvement of grassroots initiatives in the implementation of climate policy.

Acknowledgements

References

Chalganova, A. (2016). Sustainable Development and the Problem of Municipal Solid Waste Management in Russia. *Perspectives of Science, 12*(87), 135–139. (In Russian). https://doi.org/10.17323/1726-3247-2024-2-11-42

Concari, A., Kok, G., & Martens, P. (2022). Recycling Behaviour: Mapping Knowledge Domain Through Bibliometrics and Text Mining. *Journal of Environmental Management, 303*, Article 114160. https://doi.org/10.1016/j.jenvman.2021.114160

Dubois, G., et al. (2019). It Starts at Home? Climate Policies Targeting Household Consumption and Behavioral Decisions Are Key to Low-Carbon Futures. *Energy Research & Social Science, 52*, 144–158. https://doi.org/10.1016/j.erss.2019.02.001

Firmansyah, F., et al. (2024). Variation in Municipal Solid Waste Generation and Management Across Time and Space. *Resources, Conservation and Recycling, 204*, Article 107472. https://doi.org/10.1016/j.resconrec.2024.107472

Frolov, A., & Agurova, A. (2019). Index Analysis of Active Citizenship in Social Networks. *Bulletin of Irkutsk State University. Geoarchaeology, Ethnology, and Anthropology Series, 29*, 28–43. (In Russian). https://doi.org/10.26516/2073-3380.2019.29.28

Golovneva, A., & Chernysheva, L. (2017). Plastic, Bicycles and Urban Citizenships: Two Cases of Infrastructural Reorganization in St. Petersburg. *Journal of Sociology and Social Anthropology, 20*(3), 7–31. (In Russian).

Guseva, A., & Polishchuk, A. (2017). On Readiness of St. Petersburg Residents to Separate Waste: Recycling of Plastic Waste as Problem of Social Ecology. *Scientific Notes of Russian State Hydrometeorological University, 47*, 205–215. (In Russian).

Hobson, K. (2020). "Small Stories of Closing Loops": Social Circularity and the Everyday Circular Economy. *Climatic Change, 163*(1), 99–116. https://doi.org/10.1007/s10584-019-02480-z

Hobson, K., & Lynch, N. (2016). Diversifying and De-growing the Circular Economy: Radical Social Transformation in a Resource-Scarce World. *Futures, 82*, 15–25. https://doi.org/10.1016/j.futures.2016.05.012

Kasianova, A., Frolenok, V., & Chekrygin, M. (2020). The Change of Everyday Habits of People According to Current Ecological Situation. *Business Education in the Knowledge Economy, 2*(16), 65–68. (In Russian).

Kuratov, Y., & Arkhipov, M. (2019). Adaptation of Deep Bidirectional Multilingual Transformers for Russian Language. In *Computational Linguistics and Intelligent Technologies: Proceedings of the International Conference "Dialogue": Issue 18* (pp. 333–339). V.V. Vinogradov Russian Language Institute of the Russian Academy of Sciences. https://ruslang.ru/doc/stoynova/Khomchenkova&Pleshak&Stoynova-2019-NonStandRussianCorpus.pdf. (In Russian).

Litvintsev, D., Abramova, N., & Romanov, D. (2023). Separate Waste Collection: Institutional Problems of Developing Pro-Ecological Practices in Everyday Life. *Monitoring of Public Opinion: Economic and Social Changes, 3*(175), 169–185. (In Russian). https://doi.org/10.14515/monitoring.2023.3.2149

Paes, M. X. et al. (2024). Waste Management Intervention to Boost Circular Economy and Mitigate Climate Change in Cities of Developing Countries: The Case of Brazil. *Habitat International, 143*, Article 102990. https://doi.org/10.1016/j.habitatint.2023.102990

Pedregosa, F., et al. (2011). Scikit-Learn: Machine Learning in Python. *Journal of Machine Learning Research, 12*, 2825–2830.

Pupkova, Y., & Grabovskaya, E. (2019). Eco-Ducational Potential of Social Media (the Case Study of Online Communications of the Association "Separate Waste Collection"). *Information and Education: Boundaries of Communications, 19*(11), 156–158. (In Russian).

Pupysheva, I. N., Zakharova, O. V., & Kuznetsova, N. (2023). Varieties of the Discourse about Collection and Processing of Recyclable Materials: Between Pursuit of Gain and Saving the World. *Sotsiologicheskie issledovaniya, 3*, 53–65. (In Russian). https://doi.org/10.31857/S013216250020085-6

Raworth, K. (2017). *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*. Chelsea Green.

Risto, E. (2020). Waste Management System in Saint Petersburg: The Selection of the Optimal Waste. *Current Scientific Research in the Modern World, 9-2*(65), 17–20. (In Russian).

Schmid, B. (2021). Hybrid Infrastructures: The Role of Strategy and Compromise in Grassroot Governance. *Environmental Policy and Governance, 31*(3), 199–210. https://doi.org/10.1002/eet.1929

Shabanova, M. (2024). Unnecessary Items, Waste Issue and Solidarity Practices Among Russian Consumers. *Journal of Economic Sociology, 25*(2), 11–42. (In Russian).

Shalunova, E. (2013). "RazDel'nyi Sbor" – Mission Possible. *Solid Household Waste, 12*(90), 52–55. (In Russian).

Shchekotin, E., Dunaeva, D., Basina, P., & Vakhrameev, P. (2023). Digital Footprints in Ecology: Empirical Research. *Virtual Communication & Social Networks*, *2*(4), 255–263. https://doi.org/10.21603/2782-4799-2023-2-4-255-263

Tsepilova, O., & Golbraih, V. (2020). Environmental Activism: Resource Mobilisation for "Garbage" Protests in Russia in 2018–2020. *Journal of Sociology and Social Anthropology, 23*(4), 136–162. (In Russian). https://doi.org/10.31119/jssa.2020.23.4.5

Verplanken, B., & Whitmarsh, L. (2021). Habit and Climate Change. *Current Opinion in Behavioral Sciences, 42*, 42–46. https://doi.org/10.1016/j.uclim.2024.101809

Wang, D., Chen, L., & Dong, L. (2024). A Critical Review of Climate Change Mitigation Policies in the EU – Based on Vertical, Horizontal and Policy Instrument Perspectives. *Journal of Cleaner Production, 467*, Article 142972. https://doi.org/10.1016/j.jclepro.2024.142972

Zakharova, O. V., Glazkova, A. V., Pupysheva, I. N., & Kuznetsova, N. V. (2022). The Importance of Green Practices to Reduce Consumption. *Changing Societies & Personalities, 6*(4), 884–905. https://doi.org/10.15826/csp.2022.6.4.208

Zakharova, O., & Glazkova, A. (2024). GreenRu: A Russian Dataset for Detecting Mentions of Green Practices in Social Media Posts. *Applied Sciences, 14*(11), 1–17. https://doi.org/10.3390/app14114466

Zatolokin, A., & Petrov, Y. (2023). "Tire Trap" in the Urban Improvement of Tyumen: Environmental, Social and Economic Problems. *Waste and Resources, 10*(4), 1–9. (In Russian). https://doi.org/10.15862/16NZOR423

Information about the authors

Olga Zakharova (Tyumen, Russian Federation) – Professor, Public Administration Department, Measurement Test Area in Tyumen' Region (FEWZ-2024-0016), University of Tyumen (6 Volodarskogo St., Tyumen, 625003, Russian Federation; e-mail: o.v.zakharova@utmn.ru) – **corresponding author**.

Anna Glazkova (Tyumen, Russian Federation) – Assistant Professor, Software Engineering Department, Measurement Test Area in Tyumen' Region (FEWZ-2024-0016), University of Tyumen (6 Volodarskogo St., Tyumen, 625003, Russian Federation; e-mail: a.v.glazkova@utmn.ru).