

## Plastic waste management in Russia

### ABSTRACT

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The global surge in plastic production has intensified environmental crises due to inadequate waste management. In Russia, vast geography, linear economic models, and low recycling rates exacerbate the issue. This study investigates barriers to Russia's circular economy transition, focusing on fragmented policies, infrastructural deficits, and socio-economic practices. Methods include federal policy and media narrative content analysis, secondary data analysis, stakeholder interviews, and SWOT analysis. Findings indicate fragmented governance and weak Extended Producer Responsibility enforcement hinder progress. Despite emerging technologies (AI sorting, blockchain), recycling market growth, and rising awareness, infrastructural gaps and mechanical recycling limitations persist. Fossil fuel subsidies and technological isolation further complicate advancement. Effective reform requires stricter policy enforcement, bioplastics adoption, international cooperation, infrastructure decentralization, reducing petrochemical lobbying influence, and restoring public trust.

**KEY-WORDS** waste management. plastic recycling. Russian Federation. environmental policy.

## INTRODUÇÃO

The global growth of plastic production, which exceeded 460 million metric tons in 2023 (“OECD Report Examines Policy Scenarios for Ending Plastic Pollution by 2040”, [s.d.]), has intensified environmental crises, with plastic waste now permeating ecosystems from urban landfills. Russia, as the world’s largest country by landmass and a major consumer of plastics, faces unique challenges in managing its plastic waste. Approximately 3.8 million tons of plastic waste are generated annually in Russia, but only 12–15% is recycled, with the remainder landfilled or illegally dumped (MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT (MNRE), 2023). This inefficiency reflects systemic gaps in policy, infrastructure, and public engagement, positioning plastic waste management as a critical area of environmental and socio-economic concern. Russia’s waste management framework has evolved under the National Ecology Project (2019–2024) (“Национальный проект «Экологическое благополучие»”, [2024.]), which aims to achieve a 36% recycling rate for municipal solid waste (MSW) by 2024, including plastics (Government of Russia, 2018). However, legislative implementation remains fragmented. The 2020 amendment to the Federal Law On Production and Consumption Waste introduced extended producer responsibility (EPR), mandating manufacturers to fund recycling programs. Yet, enforcement has been inconsistent, with only 25% of companies complying fully (ЩУКИНА, 2023).

Meanwhile, the absence of a dedicated federal law targeting single-use plastics contrasts with the European Union’s Circular Economy Action Plan, underscoring regulatory lag. Economically, Russia’s reliance on raw material exports and underdeveloped recycling infrastructure limits progress. Investments in waste processing facilities grew by 8% in 2022, but regional disparities persist: 70% of recycling capacity is concentrated in Moscow and St. Petersburg (MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT (MNRE), 2023). Socially, public awareness of plastic pollution is rising, with 43% of citizens expressing concern in 2023 surveys (Levada Center, 2023), though waste segregation practices remain nascent in most regions. Russia’s Environmental Security Strategy (2021) sets ambitious targets: recycling 60% of MSW by 2030 and reducing landfill use by 50%. However, plastic-specific metrics are absent, reflecting a critical oversight. Current recycling rates for plastics (15%) lag behind the EU average (32%) (“Recycled Plastics Market Size & Forecast [Latest]”, [2024]) highlighting more inefficiencies. The MNRE’s 2023 report identifies key barriers: insufficient funding, weak interagency coordination, and low private-sector participation in circular economy initiatives.

This article examines the current state of plastic waste management in Russia, evaluating policy effectiveness, infrastructural capacity, and socio-economic barriers. It addresses the dissonance between legislative ambitions and on-ground realities, offering a diagnostic analysis of systemic bottlenecks. Theoretically, this study contributes to the discourse on waste management in resource-dependent economies accordingly plastic waste management, bridging gaps in literature on Russia’s post-Soviet environmental governance. Practically, it provides actionable insights for policymakers to align national strategies with global sustainability benchmarks. The findings may inform cross-border collaborations, particularly as Russia navigates sanctions-related constraints on technology imports vital for recycling innovation. This article seeks to catalyze evidence-based reforms in a critical yet underexplored domain by contextualizing Russia’s plastic waste challenges within quantitative environmental metrics and evolving policy trends.

## ENVIRONMENTAL ECONOMICS AND THE CIRCULAR ECONOMY PARADIGM

Industrial ecology conceptualizes waste as a resource through industrial symbiosis, where one sector's by-products produce another's inputs. For plastics, this could involve integrating chemical recycling outputs (e.g., pyrolysis oil) into petrochemical feedstocks. However, Russia's industrial clusters lack cross-sectoral synergies, plastic waste treated in isolation. Cradle-to-Cradle (C2C) theory demands material health and closed-loop cycles (BRAUNGART; MCDONOUGH, 2002). For plastics, this requires phasing out toxic additives and ensuring infinite recyclability. While global brands adopt C2C-certified packaging, Russia's regulatory gap on chemical safety (e.g., no REACH-like regulations) impedes progress. Traditional waste prioritize prevention over disposal but face criticism for oversimplifying socio-technical contexts (GHARFALKAR et al., 2015). In Russia, rigid adherence to recycling targets (36% MSW recycling by 2024) neglects upstream prevention, exacerbating plastic leakage into ecosystems (WWF RUSSIA, 2022).

The circular economy (CE) framework, rooted in industrial ecology and systems theory, posits that waste should be minimized through closed-loop material flows (ELLEN MACARTHUR FOUNDATION, 2019). CE principles emphasize design-for-recycling, extended producer responsibility (EPR), and the valorization of waste as a resource. Russia's nascent adoption of CE principles, as outlined in its National Ecology Project, reflects a transactional approach focused on recycling quotas rather than systemic redesign (DA SILVA and FRANZ, 2025). The dissonance between CE ideals and Russia's linear economy—driven by fossil fuel extraction and low recycling investment—echoes the "plastic paradox" described by Fredric Bauer where economic dependencies on plastics undermine sustainability transitions. The 6R, The 9R Rethink, Refuse, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover) introduces strategic prioritization, ranking actions from most sustainable (R0: Refuse) to least (R9: Recover) framework expands the circular economy paradigm by emphasizing upstream innovation (e.g., material redesign) and downstream valorization (energy recovery) (JAWAHIR; BRADLEY, 2016). For plastics, redesign entails developing polymers to avoid downcycling, while remanufacture involves reprocessing post-consumer plastics into high-value products. However, Russia's polymer industry remains dominated by virgin plastic production, with only 8% of firms investing in redesign ("Некоммерческая организация «Союз переработчиков пластмасс» - НО Союз Переработчиков Пластмасс", [2025]). (POTTING; OTHERS, 2017).

Ecological modernization theory (EMT) posits that technological innovation and market mechanisms can decouple economic growth from environmental harm (MOL; SPAARGAREN, 2000). However, Russia's plastic recycling rate (15%) revealing systemic underinvestment in technologies like chemical recycling and pyrolysis (MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT (MNRE), 2023). EMT's techno-optimism also overlooks distributive injustices: low-income regions in Russia bear disproportionate landfill burdens, also priority stays for MSW in some regions. Environmental justice frameworks thus complement EMT by highlighting spatial inequalities and advocating for inclusive policies (SCHLOSBERG, 2013). Institutional theory elucidates how formal and informal rules shape waste management systems (SCOTT, 2001). Regulatory frameworks are critical to restructuring institutional incentives. However, Russia's fragmented but centralized governance model—characterized by weak enforcement of federal

waste policies and regional autonomy—illustrates the "implementation gap" theory (HOWLETT; OTHERS, 2015). For instance, the 2020 EPR amendments lack mechanisms to penalize non-compliant producers, leading to "free-riding" behaviors.

Psychological theories, including the value-belief-norm model (STERN, 2000), link pro-environmental behavior to personal values and perceived efficacy. In Russia, educational campaigns by NGOs (e.g., Ecoline's school programs) have increased youth awareness but face resistance from older generations accustomed to Soviet-era disposability norms (SAUTKINA et al., 2021). To effectively promote pro-environmental behavior across different age groups in Russia, it is essential to align values, beliefs, and norms with the long-term principles of sustainable development, immediate motivations.

The knowledge-deficit model, critiqued for oversimplifying behavior change (BURGESS; OTHERS, 1998), remains prevalent in Russian policy. For instance, the MNRE's 2022 plastic reduction campaign emphasized informational pamphlets over structural incentives. Behavioral economics further explains inertia in waste management through cognitive bias and nudging (THALER; SUNSTEIN, 2008). For example, despite 43% of Russians expressing environmental concern, only 18% regularly segregate waste by their own initiative for more types of plastic in special infrastructure, and this is reflecting a gap between intention and action (AJZEN, 1991). Plastic dependence is reinforced by lock-in theory, where entrenched systems (e.g., fossil fuel subsidies, consumer habits) resist transition (UNRUH, 2000). Russia's oil-dependent economy subsidizes virgin plastic production at 3x the rate of recycling (Institute for Energy and Finance, 2023), creating perverse incentives. ). Social practice theory (SPT) shifts focus from individual choices to the socio-material routines that normalize plastic consumption (Shove et al., 2012). Social practice theory further explains inertia through plastics as infrastructure: single-use packaging is embedded in retail logistics, hospitality, and urban lifestyles (SHOVE, 2010). To overcome the inertia of plastic infrastructure, institutional practices must be interconnected across all levels—from manufacturers to consumers and from consumers to recyclers—through efficient supply chains and motivational frameworks. These practices, in turn, reinforce the values, beliefs, and norms that drive sustainable behavior, creating a feedback loop that aligns economic incentives with environmental responsibility. In Moscow, 78% of takeaway outlets use SUPs due to cost and convenience (ECOLINE, 2023), illustrating path dependency. Interventions such as deposit-refund systems (DRS), proven effective in European countries (GEYER; JAMBECK; LAW, 2017), remain untested at scale in Russia. In Russia, this integration is hindered by siloed policymaking and a lack of interdisciplinary research. Recent studies advocate for "polycentric governance" (OSTROM, 2010), combining federal mandates with grassroots initiatives—an approach yet to gain traction in Russia's top-down system. Its need the interdisciplinary approach necessary for redesign environmental material flows, institutional analysis needed to strengthen governance, with behavioral insights to shift social practices, and justice-oriented frameworks to address equal environmental ecosystem services.

## METHODOLOGY AND METHODS

This study employs a tripartite methodological approach to dissect the complexities of plastic quantitative, and diagnostic frameworks. The methodology is designed to triangulate data across institutional, operational, and socio-political dimensions of systemic challenges and opportunities.

1. Content Analysis of policy documents, scientific literature, and media sources

Data Sources content policy documents, federal and regional legislation (e.g., National Ecology Project, EPR amendments), national and international reports (2018–2025). In addition to official documents was used peer-reviewed articles on circular economy, waste governance, and plastic pollution in Russian contexts (Scopus/Web of Science databases, Russian national library 2010–2025). Media Analysis resources was applied for coverage from state-affiliated analytics to gauge public and political narratives.

Analytical process firstly used thematic coding using manually categorizing data into policy coherence, stakeholder roles, technological adoption, and public engagement. Content analysis examined strategies in policy texts (for example, “recycling targets” vs. “waste elimination”) to identify ideological priorities.(FAIRCLOUGH, 2003)

2. Secondary using data analysis based on expert Interviews (n=60), recycling rates (MNRE, Rosstat), plastic production figures (Russian Union of Industrialists and Entrepreneurs), and landfill leakage metrics. Expert Interviews was collected in 2023 with semi-structured anonymization of participants guide with purposive waste management in Russia, integrating qualitative,

- waste recycling industry from different fields and recycling startups.
- governmental regional waste management officers.
- academia: environmental economists, polymer and social scientists
- NGOs leaders.

3. Integrated SWOT analysis with synthesis of Findings for thematic outputs from content analysis and expert interviews. In the article used classic SWOT matrix construction: strengths, weaknesses, opportunities, and threats were derived through inductive coding of triangulated data.

## RESULTS AND DISCUSSION

Currently, Russia accounts for approximately 3% of global plastic production, reflecting a relatively modest share in the industry. However, projections by the Russian Ministry of Economic Development indicate significant growth in the industrial output of rubber and plastic products. Production levels were expected to reach 120.6% of the 2025 baselineThis translates to an annual growth rate of 5–5.5%, signaling a rapid expansion of the sector.

Aligned with these trends, Russia’s «Strategy for the Development of the Chemical and Petrochemical Complex through 2030» outlines a dramatic increase in per capita plastic consumption. The plan anticipates a jump from 32.3 kg per person in 2012 to 89.8 kg per person by 2030(“Рынок базовых полимеров 2020. На гребне второй волны”, 2020). While this reflects growing industrial and consumer demand, it also raises concerns about escalating plastic pollution,

underscoring the urgent need for robust regulatory and environmental measures to mitigate the impact.

The surge in plastic production and consumption has directly correlated with a rise in plastic waste. According to Russia's Ministry of Industry and Trade, the country generates between 3.6 and 5 million tons of plastic waste annually. Recycling rates, however, remain low, with estimates suggesting only 7–20% of this waste is processed ("На гребне токсичной волны", 2020). These figures vary significantly depending on the type of plastic, as some materials face technical or economic barriers to recycling ("Об утверждении Стратегии развития химического и нефтехимического комплекса на период до 2030 года от 08 апреля 2014 - docs.cntd.ru", [s.d.]). The disparity highlights systemic challenges in waste management infrastructure and the necessity for targeted policies to improve recycling efficiency and reduce environmental harm.

This combination of accelerating production, rising consumption, and inadequate waste processing points to a critical juncture for Russia in balancing industrial growth with environmental sustainability.

Over the past two decades, the proportion of plastic in municipal solid waste (MSW) has nearly doubled, rising from 3–4% in the 1990s to 5–10% today. While this increase may seem modest by volume, plastic's financial share of waste is disproportionately higher due to its elevated cost compared to other common waste materials, such as paper and glass ("ЭКОНОМИКИ", 2018).

Breaking down the composition of plastic waste, packaging dominates at 42%, followed by plastic film (35%), PET bottles (12%), and other polymer-based waste (11%). This distribution underscores the prevalence of single-use and disposable plastics in everyday consumption.

Efforts to address recycling challenges have seen incremental progress. For instance, the introduction of a dual-container waste segregation system in 2019 has boosted the collection of recyclable plastics by 1.5 times compared to the same period in 2019 prior to its implementation. This shift reflects broader reforms in waste management infrastructure.

By the end of 2024, Russia recycled approximately 7.3–7.9 million tons of plastics, with secondary polymers accounting for 850,000–900,000 tons (12% of total plastic waste generated). While this figure remains slightly below the global average of 14%, it reflects incremental growth in recycling infrastructure. Recent years have seen the emergence of high-capacity facilities, such as the EcoLine-VtorPlast complex in Yegoryevsk (60,000 tons/year) and TotalCycle in Tver (40,000 tons/year), alongside upcoming projects like RT-Invest's 100,000-ton plant in Kashira. These facilities, supported by public-private partnerships and foreign investments, signify efforts to scale industrial recycling capacity. Aggregators such as the state-owned Russian Environmental Operator (REO) further bolster the ecosystem through digital platforms for secondary raw material trading, with polymer waste dominating transactional volumes.

However, systemic challenges hinder progress toward a circular economy. Despite infrastructure expansion, the sector faces a critical shortage of high-quality secondary feedstock. Only 40% of municipalities employ dual-container waste segregation, resulting in limited recovery of post-consumer plastics from mixed municipal solid waste (MSW). Recycling plants increasingly rely on contaminated landfill waste, necessitating costly multi-stage washing and filtration processes. Even advanced facilities struggle to produce compliant recycled granules, as residues of detergents or oils persist. Regulatory constraints exacerbate these

issues: Roskomnadzor permits a maximum of 30% recycled content in food-grade packaging, deterring manufacturers from adopting post-consumer materials. Industry reliance on pre-consumer industrial scrap (65–80% of feedstock) underscores the underutilization of MSW-derived plastics, which face lower market demand due to perceived quality risks (“Переработка пластика”, [s.d.]).

Legislative reforms, such as revised Extended Producer Responsibility (EPR) frameworks, aim to incentivize circularity by shifting eco-tax burdens to producers and mandating 100% packaging recycling by 2027. Yet, compliance costs disproportionately affect polymer industries, with projected annual penalties reaching 924 billion RUB if current waste volumes persist. Technological stagnation remains a bottleneck: mechanical recycling dominates (80% of operations), while advanced methods like chemical depolymerization or solvent-based processes remain experimental. Experts emphasize the need for R&D collaboration with scientific institutions to overcome these barriers. Without systemic upgrades to sorting infrastructure, regulatory harmonization, and investment in chemical recycling, Russia’s circular economy transition will remain constrained by fragmented systems and quality deficits in secondary material streams (“Вторичная переработка пластмасс”, 2025).

Russia’s progress toward a green economy can be partially evaluated through its evolving approach to plastic waste management, where systemic reforms and infrastructural investments intersect with persistent challenges. According to the Russian Ministry of Trade, the country currently operates approximately 500 recycling facilities. While this infrastructure signifies a foundational capacity for circular practices, its efficiency remains constrained by structural and operational limitations, reflecting both advancements and gaps in sustainable development.

Mechanical recycling dominates Russia’s plastic processing sector, with facilities primarily handling four categories of polymers: PET bottles (marking 1), used predominantly in beverage containers; HDPE packaging (markings 2 and 5), including canisters and cosmetic bottles; LDPE films and bags (marking 4), common in disposable packaging; and polypropylene (marking 5), employed in food containers and automotive components.

Table1 - Types of plastic, production and recycling rates

| Plastic Type              | Production Volume     | Recycling Rate | Key Characteristics                                                                                                            |
|---------------------------|-----------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------|
| <b>Polyethylene (PE)</b>  | 3 million tons (2020) | ~10-15%        | Dominates production, used in packaging and construction. Low recycling due to mixed waste streams and limited infrastructure. |
| <b>Polypropylene (PP)</b> | Not specified         | ~8-12%         | Common in automotive and consumer goods. Recycling hindered by contamination and lack of sorting.                              |
| <b>PET (Bottles)</b>      | Significant           | 24-26%         | Most recycled type due to established collection systems.                                                                      |
| <b>Polystyrene (PS)</b>   | Not specified         | <5%            | Rarely recycled due to lightweight structure and economic unviability; often landfilled.                                       |

Sources: (GOVERNMENT OF THE RUSSIAN FEDERATION, 2024; VANTAGE MARKET RESEARCH, 2025)

Trends for different types of plastic recycling differs: For example PET Recycling dominates the market (24-26% of recycled plastics), driven by beverage

industry commitments to 30% recycled content by 2030. The Polyolefins (HDPE, LDPE) demand grows in construction (recycled pipes) and packaging, with a projected 18% CAGR in HDPE recycling. The Chemical recycling presented as pilot projects by Sibur and Tatneft aim to scale pyrolysis and gasification, targeting 200,000 tons/year capacity by 2030.

These materials are largely sourced from industrial and commercial waste streams, which are easier to reintegrate into production cycles due to their relative cleanliness and homogeneity. Municipal solid waste (MSW), by contrast, remains underutilized, with only 7–20% of plastic waste recycled nationally. This disparity stems from inadequate segregation systems, limited sorting infrastructure, and low public participation in waste separation programs—factors that hinder the recovery of high-quality recyclables from households (CROSS WRAP, 2025).

Legislative efforts to address these gaps have intensified in recent years. The Concept for Improving Extended Producer Responsibility (EPR), ratified in December 2020, represents a cornerstone policy aimed at enhancing accountability among manufacturers for the lifecycle of their products. A subsequent Implementation Roadmap (April 2021) outlines strategies to digitize waste management through a federal electronic platform for tracking MSW flows and creating a catalog of product packaging specifications. These measures align with ambitious targets, including achieving 100% MSW processing and halving landfill deposits by 2030. However, the practical realization of these goals faces hurdles, such as uneven regional implementation of dual-container collection systems and insufficient investment in advanced sorting technologies.

The reliance on mechanical recycling further exposes systemic vulnerabilities. While effective for homogeneous industrial waste, this method struggles with mixed or contaminated plastics from MSW, which require more sophisticated chemical or energy recovery processes. Consequently, Russia's recycling sector remains disproportionately dependent on pre-consumer waste, limiting its capacity to address the growing volume of post-consumer plastics—a problem exacerbated by rising per capita plastic consumption, projected to reach 89.8 kg annually by 2030.

From an analytical perspective, Russia's alignment with green economy principles reveals a dual narrative. On one hand, policy frameworks and infrastructural expansions reflect a growing institutional commitment to sustainability. On the other, persistent inefficiencies in waste segregation, low recycling rates, and technological stagnation underscore a significant lag behind global leaders in circular economy practices (ABRAMOVA, 2021). The nation's ability to close this gap will hinge on accelerating investments in sorting infrastructure, fostering public-private partnerships for innovation, and ensuring stricter enforcement of EPR mandates. Until these steps are realized, Russia's transition to a green economy will remain incremental, characterized by partial progress amid enduring structural constraints.

This analysis employs a multi-criteria framework to assess green economy alignment, weighing policy ambition, infrastructural capacity, recycling efficiency, and public engagement. Russia demonstrates moderate progress in policy design but lags in implementation coherence and technological adoption, positioning it in an intermediate phase of transition—advancing toward sustainability objectives but requiring systemic upgrades to achieve transformative outcomes.

Russia's plastic waste governance can be characterized as a centralized and fragmented system dominated by state-corporate coalitions, with marginalized

civil society participation. This model reflects a hybrid of neopatrimonialism (power concentration among elites) and resource nationalism (prioritizing extractive interests over sustainability)(SPERANSKAYA et al., 2021; TYNKKYNNEN, 2024).

### Key actors and power distribution:

1. State actors: Ministry of Natural Resources and Environment (MNRE): The primary regulator, shaping federal strategies (e.g., National Ecology Project), struggles to coordinate regions(MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT (MNRE), 2023). Regional Authorities formally autonomous but reliant on federal funding and depending from the national environmental law system(CROTTY; AND LJUBOWNIKOW, 2023). Rosprirodnadzor (Environmental Supervision Service) monitors compliance enforcement capacity due to corporate lobbying(SAUNDERS, 2016).

2. Corporate Sector: petrochemical giants (oil and oil post production companies - Sibur, Rosneft, Lukoil, Tatneft, etc.): Dominate via lobbying for low virgin plastic taxes and blocking single-use plastic bans (Institute for Energy and Finance, 2023). Regional waste Operators control 60% of recycling markets but focus on profitable streams (e.g., PET bottles), neglecting complex waste(MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT (MNRE), 2023). The main problems for the private waste recycling companies are not always enough loaded with sufficient capacity for plastic recycling, also lack of financial loan and governmental support made this niche difficult to develop from the business point of view in comparison with economical instruments support in EU and BRICS countries for waste projects. Now the law frame of the waste management control in the process of reframing, and business actively try to promote the interests and provide the necessary level of the responsibility. The chains between different corporate actors sub-actors built in concepts of national huge techno parks, linked to different stages of LCA of oil and plastic production, manufacturing and recycling. In comparison to governmental consortiums, appeared the local smaller recycling actors.

The nexus between the Russian state and petrochemical corporations exemplifies neopatrimonial governance, where formal institutions are subverted by patronage networks. As example of the case, petrochemical companies like Sibur and Tatneft fund state-led infrastructure projects (landfill modernization, AI-powered sorting facilities) in exchange for regulatory leniency. For instance, Sibur's financial contributions to the National Ecology Project secured exemptions from stringent Extended Producer Responsibility (EPR) requirements, allowing the firm to minimize recycling obligations while expanding virgin plastic production. This quid pro quo perpetuates a resource curse dynamic, where fossil fuel dependencies distort policy priorities. Sibur co-drafted the 2020 EPR amendments, ensuring clauses that prioritize voluntary compliance over penalties. Consequently, only 25% of companies report full adherence, while 60% of plastic packaging remains non-recyclable (Sibur, 2023)(“Вторичная переработка и использование пластика”, [s.d.]). Drawing on Martinez-Alier's framework of “environmentalism of the poor”, Russia's plastic waste regime exemplifies systemic environmental injustice, where marginalized regions bear disproportionate ecological burdens(MARTINEZ-ALIER et al., 2016). For examples Siberia hosts 80% of Russia's landfills, including toxic sites near Indigenous

communities like the Khanty and Nenets. As worldwide, microplastics and leachate from Moscow's waste have contaminated local water sources. Landfills at the same time can be appreciate at the resource of the recycle plastic.

The metabolic rift (FOSTER, 1999) between Russia's extractive economy and ecological imperables is stark. Plastic production (3 million tons/year) relies on subsidized naphtha from state-owned oil firms (Rosneft, Gazprom Neft), creating a carbon lock-in (Unruh, 2000).

3. Civil society and NGOs can advocate for reforms and often support grassroots Initiatives. Environmental NGOs mostly not strongly involved in policymaking, reflecting authoritarian environmentalism (Beeson, 2010), where dissent is framed as destabilizing until resource extraction linked with national identity. Accordingly to different sociological research, the activity of waste separate activity of the citizens increases, especially in huge cities, participation in environmental social practices of the society depends from the personal comfort, environmental regional norms, environmental attitudes, trust level and satisfaction for work of the regional operator. The international NGO activity provided the waste management knowledge lessons and activities, especially about types of plastic waste, environmentally responsible social practices events among the population, after the sanctions these organizations stopped their activity, but local and the most strong Russian NGOs continue their own environmental programmes.

4. Academia and research institutions can participating in framing of the generate circular economy insights, provide innovative research in technology of waste management systems but recommendations rarely inform policy due to bureaucratic silos(MIHAI et al., 2022). Some federal-priority regions, linked with petroleum postproduction, more developed as the the center of raw base model of the economy. This centralization reflects core-periphery theory, where economic and political power clusters in urban hubs not active. Science-Policy gap can be determined as the luck of academic research on bioplastics and eco-design (e.g., Novosibirsk State University's mycelium packaging) and plastic recycling. The academia actively not informs policy. The 2023 MNRE report ignored peer-reviewed recommendations to phase out SUPs, prioritizing short-term GDP metrics over circular transitions. Bureaucratic inertia and regulatory capture by petrochemical lobbies can stifle circular innovation.

The plastic waste recycling sector in Russia is undergoing a gradual but uneven transformation, driven by federal recycling targets and global sustainability trends. According to the National Ecology Project (2019–2024), the government aims to create 50,000 new jobs in waste management by 2030, with a focus on modernized recycling facilities and circular economy initiatives. While official statistics on sector-specific employment remain sparse, regional reports indicate growth in material recovery facilities (MRFs) and chemical recycling plants, particularly in Moscow, Tatarstan, and Kaliningrad. For instance, Moscow's AI-powered MRFs have expanded their workforce by 15% since 2021, hiring technicians and data analysts to operate advanced sorting systems in, for example, Ecoline company. Conversely, informal waste pickers, who handle an estimated 20% of recyclables, remain marginalized, lacking social protections or formal recognition(EPMO/IAEBA, 2020).

The Ministry of Industry and Trade forecasts a 25% increase in demand for PET recycling specialists by 2025, driven by partnerships between petrochemical firms and global brands (e.g., PepsiCo) to meet recycled content targets (Ministry

of Industry and Trade, 2022). Additionally, the bioplastics sector, though nascent, is projected to grow by 12% annually, requiring chemists and agricultural engineers to develop feedstocks from wheat and hemp. However, rural regions lag due to infrastructural deficits, with only 3% of recycling jobs located outside major cities.

### Expert opinions's analysis:

#### 1. Current State of Plastic Waste Management

Russia's plastic waste management system is marred by structural fragmentation and inconsistent implementation of policies. The 2020 introduction of dual-stream waste segregation (gray bins for mixed waste, blue for recyclables) aimed to align with global best practices. However, experts emphasize that poor public awareness and infrastructure gaps have rendered the system ineffective. For instance, environmental engineers observed, "Blue bins are often treated as general waste receptacles. Contamination rates exceed 40%, making sorted plastics economically unviable for recycling" (Informant 3). Regional operators like "Эколайн" have introduced financial incentives for reporting violations, such as mixed waste in recycling bins, but participation remains low.

A significant portion of plastic waste management is controlled by actors who prioritize high-value materials like metals from e-waste, while non-lucrative plastics are discarded. This economy operates regulatory oversight, exacerbating environmental harm. "In Siberia, scavengers dismantle electronics in illegal workshops, extracting copper wires and dumping PVC casings into rivers," reported an environmental NGO director (Informant 6). Some cities recycling facilities, process only 8–10% of PET and HDPE, while mixed plastics (LDPE films, polystyrene) are ignored due to technological limitations. "We lack the machinery to handle multilayered packaging," admitted a plant manager (Informant 12).

#### 2. Conceptual Frameworks and Systemic Challenges of the Plastic Waste Management

Russia's plastic management aligns with a linear economy model (produce-use-dispose), directly contradicting the waste management hierarchy (Lansink scheme), which prioritizes prevention and recycling. Experts attribute this to weak legislative enforcement of EPR. Unlike the EU, where manufacturers fund recycling through schemes like the "Green Dot," Russian producers face minimal accountability. "A chip bag here contains aluminum, plastic, and ink—it's designed for profit, not recyclability," criticized a packaging designer (Informant 7). This disregard for eco-design perpetuates reliance on landfills.

The Circular Economy framework, which advocates for closed-loop material cycles, remains unimplemented at scale. A key barrier is the absence of integrated systems for collection, sorting, and reprocessing. "We have 'islands' of recycling—PET bottles in Tver, HDPE in Chelyabinsk—but no national network," noted a policy analyst (Informant 10).

#### 3. Divergent Expert Perspectives

Proponents of technological solutions advocate for AI-driven sorting systems to address contamination. "Optical sorters with near-infrared sensors can distinguish PET from PVC at 99% accuracy, doubling recycling yields," argued a robotics engineer (Informant 9). However, skeptics emphasize behavioral change as the cornerstone of success. Switzerland's model—where households segregate waste into 12 categories under threat of fines—achieved 52% recycling

rates. “Technology alone won’t work without cultural shifts. Russians need to see recycling as a civic duty, not a chore,” countered a behavioral scientist (Informant 15).

Federal Law No. 89-FZ (1998) delegates waste management to regional operators, but enforcement is absent. In some cities, mismanagement has led to methane leaks from organic-contaminated landfills. “The law is a paper tiger. Operators face no penalties for dumping recyclables with general waste,” lamented a legal scholar (Informant 8). Conversely, St. Petersburg’s experimental “zero-waste” districts—with separate bins for glass, metal, and biowaste—show promise but lack funding for scaling. “Without federal grants, these pilots will collapse,” warned a municipal officer (Informant 11).

State-backed waste-to-energy projects, like the Kazan incinerator, are polarizing. Proponents argue incineration reduces landfill dependency and generates electricity. “Modern filters capture 99% of particulates, aligning with EU emission standards,” claimed a project engineer (Informant 16). Critics, however, highlight Life Cycle Assessment (LCA) gaps: burning plastics releases CO<sub>2</sub> and toxicants like furans. “Incineration perpetuates fossil fuel dependency. Microplastics from ash contaminate soil for centuries” (Informant 13).

#### 4. Future Projections and Policy Recommendations

Experts urge adopting EU-style EPR laws to force producers to design recyclable packaging and fund collection systems. Germany’s “Green Dot” system reduced packaging waste by 1.8 million tons annually since 1991. “Taxing non-recyclable plastics would incentivize mono-material designs” (Informant 10).

Chemical recycling methods, such as pyrolysis, can process mixed plastics into synthetic fuels or feedstocks. “Siberian trials converted 70% of LDPE films into diesel, but subsidies are needed for commercialization,” shared a chemical engineer (Informant 17). Deposit-refund systems for PET bottles, modeled on Norway’s 95% return rate, could also curb littering.

Japan’s hyper-segregation model, with 20+ waste categories, demonstrates the power of community engagement. “Local ‘eco-ambassadors’ in Osaka train households to wash and sort waste. Similar grassroots programs could work in Russia,” suggested a sociologist (Informant 19). Gamification, like Sweden’s Pantamera app—which rewards users for recycling—could enhance participation among youth.

Russia’s ratification of the Basel Convention’s 2021 plastic amendments would restrict exports and spur domestic innovation. “Adopting EU circular economy benchmarks isn’t optional—it’s existential,” (Informant 20). Partnerships with Nordic countries could transfer expertise in waste-to-energy and material recovery.

Russia’s plastic waste crisis is a microcosm of broader governance failures, yet it presents an opportunity for transformative change. Russia could transition from a linear “take-make-dispose” model to a sustainable system. As a Moscow policymaker concluded, “The choice is stark: innovate or become a global landfill” (Informant 14).

The following SWOT analysis evaluates the internal strengths and weaknesses, alongside external opportunities and threats, shaping Russia’s capacity to manage plastic waste. It integrates quantitative data, policy dynamics, and socio-technical factors to diagnose systemic challenges and latent potential.

Table 2 - SWOT analysis

| Strengths (S)                                                                                                                                | Weaknesses (W)                                                                                                                                                                     |
|----------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Federal Initiatives: <i>National Ecology Project</i> (2019–2024) and <i>Environmental Security Strategy</i> (2021) set recycling targets. | 1. Infrastructure Gaps: Only 7-20% (depends from type of waste) of plastic waste recycled; 70% of processing capacity concentrated in Moscow/St. Petersburg and industrial regions |
| 2. Resource Potential: Vast agricultural land for bio-based plastic feedstocks (wheat straw).                                                | 2. Fragmented Governance: Weak enforcement of EPR laws; regional disparities in policy implementation.                                                                             |
| 3. Public Awareness: Rising environmental concern and youth-led NGOs promoting waste segregation.                                            | 3. Linear Economy Lock-In: Fossil fuel subsidies incentivize virgin plastic production.                                                                                            |
| 4. Emerging Tech Hubs: Pilot AI sorting systems in Kazan and blockchain traceability projects.                                               | 4. Limited Private Investment: Only 8% of firms invest in circular design.                                                                                                         |
| Opportunities (O)                                                                                                                            | Threats (T)                                                                                                                                                                        |
| 1. Circular Tech Adoption: AI sorting, chemical recycling, and decentralized pyrolysis units could bridge infrastructure gaps.               | 1. Fossil Fuel Dependence: Oil/gas revenues hinder transition to circular plastics .                                                                                               |
| 2. EPR Expansion: Stricter enforcement and eco-modulation fees could boost producer accountability.                                          | 2. Sanctions Constraints: Limited access to Western recycling technologies.                                                                                                        |
| 3. Bioplastics Market: Global demand for compostable plastics aligns with Russia's agro-resources.                                           | 3. Climate Vulnerabilities: Thawing permafrost destabilizes landfills, increasing leakage risks                                                                                    |
| 4. Cross-Border Collaboration: Partnerships with Asian states for waste tech and circular models.                                            | 4. Public Resistance: Low trust in waste reforms; oppose landfill fees.                                                                                                            |

Source: authors.

**Strengths:** Russia's federal strategies, such as the National Ecology Project, provide a legislative scaffold for waste management, albeit with uneven regional implementation. Emerging tech pilots and growing eco-consciousness among urban youth signal latent potential for systemic shifts. However, strengths are undercut by infrastructural centralization and fossil fuel dependencies.

**Weaknesses:** The dominance of linear economic models, reinforced by \$4.2 billion in annual fossil fuel subsidies, perpetuates reliance on virgin plastics. Fragmented governance—evidenced by inconsistent EPR compliance (25% of firms)—reflects a lack of political will to prioritize circularity. Rural regions remain marginalized, with 40% lacking formal waste collection (MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT (MNRE), 2023).

**Opportunities:** Adopting advanced recycling technologies (enzymatic breakdown) could mitigate low recycling rates, while bioplastics derived from wheat straw align with global sustainability trends. Strengthening EPR through eco-modulation fees would incentivize circular design. Cross-border tech partnerships, particularly with China's booming waste-tech sector, offer pathways to bypass Western sanctions.

**Threats:** Russia's fossil fuel economy creates a structural barrier: virgin plastic production is 30% cheaper than recycling due to subsidies ("OECD Report Examines Policy Scenarios for Ending Plastic Pollution by 2040", [s.d.]). Sanctions further

isolate Russia from cutting-edge recycling innovations, while climate change exacerbates existing risks—e.g., Arctic plastic leakage from thawing landfills. Public skepticism toward waste reforms, rooted in Soviet-era disposability norms, complicates behavioral shifts (AXON et al., 2018).

## CONCLUSION

Russia's struggle to reconcile its plastic waste management ambitions with the realities of a linear, resource-dependent economy underscores the complexities of transitioning to a circular model. While this study identifies systemic barriers—policy fragmentation, infrastructural centralization, and regulatory capture by petrochemical interests—it also highlights latent opportunities for transformative change. Future research should prioritize interdisciplinary approaches to address gaps in three key areas. First, techno-economic analyses of decentralized recycling systems, such as pyrolysis units or blockchain-enabled traceability platforms, could assess their viability in mitigating Russia's infrastructural disparities. Second, comparative governance studies across BRICS may reveal adaptive strategies to circumvent sanctions-driven technological isolation, particularly in scaling chemical recycling and bioplastics production. Finally, social practice theory applications could deepen understanding of how Soviet-era disposability norms intersect with emerging eco-consciousness, informing targeted behavioral interventions. Theoretical frameworks like post-growth economics and decolonial sustainability offer fresh lenses to critique Russia's fossil fuel lock-in and reimagine waste governance beyond extractive paradigms. Additionally, life cycle assessments (LCAs) of Russia's nascent waste-to-energy projects must evaluate long-term trade-offs between emission reductions and microplastic dispersion, ensuring alignment with planetary boundaries.

As global plastic treaties gain momentum, Russia's role as a petrochemical exporter necessitates reevaluating its economic dependencies through the lens of ecological debt and just transition principles. Collaborative research with Nordic or Asian partners on cross-border recycling networks could bypass current technological constraints while testing hybrid governance models. Ultimately, this article calls for a paradigm shift—from diagnosing inefficiencies to co-designing resilient, equitable systems—that positions Russia not as a peripheral player but as a laboratory for innovative, context-specific solutions in the global fight against plastic pollution.

## Gestão de resíduos plásticos na Rússia

### ABSTRACT

O aumento global da produção de plásticos intensificou crises ambientais devido ao manejo inadequado de resíduos. Na Rússia, a vasta geografia, os modelos econômicos lineares e as baixas taxas de reciclagem agravam o problema. Este estudo investiga as barreiras à transição da Rússia para a economia circular, com foco em políticas fragmentadas, déficits de infraestrutura e práticas socioeconômicas. Os métodos incluem análise de conteúdo de políticas federais e de narrativas midiáticas, análise de dados secundários, entrevistas com partes interessadas e análise SWOT. Os resultados indicam que a governança fragmentada e a fraca aplicação da Responsabilidade Estendida do Produtor (REP) dificultam o progresso. Apesar das tecnologias emergentes (triagem por IA, blockchain), do crescimento do mercado de reciclagem e do aumento da conscientização, persistem lacunas de infraestrutura e limitações da reciclagem mecânica. Subsídios a combustíveis fósseis e isolamento tecnológico complicam ainda mais o avanço. Reformas eficazes exigem aplicação mais rigorosa de políticas, adoção de bioplásticos, cooperação internacional, descentralização da infraestrutura, redução da influência do lobby petroquímico e restauração da confiança pública.

**KEY-WORDS:** gestão de resíduos. reciclagem de plástico. Federação Russa. política ambiental.

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