

Legal mechanisms for reducing microplastic pollution: an analysis of policy gaps and regulatory solutions

Pravni mehanizmi za smanjenje zagađenja mikroplastikom: analiza nedostataka u zakonodavstvu i regulatorna rešenja

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Abstract: Microplastic pollution has emerged as a critical environmental challenge, posing significant risks to ecosystems, human health, and biodiversity. Regulatory frameworks for microplastic pollution prevention are evolving globally, addressing sources, distribution, and impacts of microplastics in marine and terrestrial environments. These regulations focus on controlling the production, use, and disposal of plastic products that break down into microplastics. Key strategies include implementing restrictions on single-use plastics, promoting circular economy principles, and enhancing waste management practices. Moreover, the regulation of microplastics in industrial applications, such as cosmetics, cleaning products, and textiles, is becoming increasingly stringent. International bodies, including the United Nations and the European Union, have initiated collaborative efforts to harmonize regulations, improve scientific understanding, and establish monitoring standards for microplastic contamination. This paper explores the current regulatory framework, particularly in the Republic of Serbia, identifies gaps in enforcement, and proposes strategies for a more effective response to microplastic pollution, emphasizing the need for cross-sectoral coordination and comprehensive public engagement.

Keywords: waste, plastic, microplastic, pollution.

Sažetak: Zagađenje mikroplastikom se pojavilo kao kritičan ekološki izazov, koji predstavlja značajan rizik za ekosisteme, zdravlje ljudi i biodiverzitet. Regulatorni okviri za prevenciju zagađenja mikroplastikom se globalno razvijaju, baveći se sa izvorima, distribucijom i uticajima mikroplastike u morskom i kopnenom okruženju. Ovi propisi se fokusiraju na kontrolu proizvodnje, upotrebe i odlaganja plastičnih proizvoda koji se raspadaju u mikroplastiku. Ključne strategije uključuju primenu ograničenja na plastiku za jednokratnu upotrebu, promovisanje principa cirkularne ekonomije i unapređenje praksi upravljanja otpadom. Štaviše, regulisanje mikroplastike u industrijskoj primeni, kao što su kozmetika, proizvodi za čišćenje i tekstil, postaje sve stroža. Međunarodna tela, uključujući Ujedinjene Nacije i Evropsku Uniju, pokrenula su zajedničke napore na harmonizaciji propisa, poboljšanju naučnog razumevanja i uspostavljanju standarda za praćenje kontaminacije mikroplastikom. Ovaj rad istražuje trenutni regulatorni okvir, posebno u Republici Srbiji, identifikuje nedostatke u primeni i predlaže strategije za efikasniji odgovor na zagađenje mikroplastikom, naglašavajući potrebu za međusektorskom koordinacijom i sveobuhvatnim angažovanjem javnosti.

Ključne reči: otpad, plastika, mikroplastika, zagađenje.

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INTRODUCTION

According to the United Nations Environment Programme (UNEP), microplastics are defined as solid plastic particles measuring less than 5 millimeters in diameter. These particles are characterized by their persistence in the environment, as they are neither biodegradable nor soluble in water.

Microplastics can be generally classified into two categories based on their origin: primary and secondary microplastics. Primary microplastics are intentionally manufactured for use in a variety of products, including cosmetic formulations and cleaning agents, where they serve specific functional purposes. In contrast, secondary microplastics are formed unintentionally as a result of the degradation and mechanical breakdown of larger plastic materials. These particles typically arise as by-products during waste management processes such as the separation, storage, washing, grinding, and extrusion of plastic waste.

This paper examines the development of policies addressing microplastics derived from waste, with the aim of identifying effective legislative and regulatory strategies to mitigate plastic pollution.

The first section provides an overview of EU policies and trends in microplastic pollution, the second section focuses on existing policies in the Republic of Serbia, while the third section offers recommendations for policy reforms in Serbia aimed at enhancing the prevention of microplastic generation.

In the course of writing the paper, comparative method was employed, with observation serving as the primary research tool.

1. EU WASTE POLICIES IN MICROPLASTIC PREVENTION AND REDUCTION

Policies aimed at the prevention of secondary microplastic pollution are increasingly recognized as essential components of comprehensive plastic governance frameworks. Unlike primary microplastics, which can be regulated at the point of production, secondary microplastics present a greater regulatory challenge due to their diffuse and often unintentional formation during the degradation of plastic products. Current policy approaches typically address secondary microplastics through broader waste management and environmental protection legislation, with particular emphasis on improving plastic collection systems, encouraging material recovery, and minimizing plastic leakage into terrestrial and aquatic environments. Measures such as mandatory extended producer responsibility (EPR) schemes, the development of product design

standards that reduce fragmentation, and investment in advanced waste treatment technologies have shown potential in mitigating secondary microplastic release. However, despite these advancements, significant gaps remain - particularly in the areas of enforcement, monitoring, and the integration of microplastic-specific criteria into existing permitting and environmental impact assessment procedures. As such, a more targeted policy framework is required, one that includes specific provisions for identifying high-risk plastic applications, regulating key industrial processes (e.g., mechanical recycling), and promoting innovation in alternative materials and closed-loop systems.

The European Union has been at the forefront of addressing microplastic pollution through a series of directives and regulations aimed at reducing plastic waste and controlling the release of microplastics into the environment.

The EU's European Strategy for Plastics in a Circular Economy (2018) is a comprehensive policy initiative designed to address the entire lifecycle of plastics. It includes a commitment to reducing plastic waste, promoting recycling, and curbing microplastic pollution. The strategy is framed within a broader push toward a circular economy, where materials are reused, recycled, and kept in use for as long as possible.

The Directive on Single-Use Plastics (SUP Directive) aims to reduce the environmental impact of plastic waste, particularly single-use plastic products. It includes measures to reduce plastic waste in aquatic environments, addressing secondary microplastic pollution caused by, for example, plastic litter.

Waste Framework Directive (2008/98/EC) lays out the EU's waste management policies and encourages waste prevention, the reuse of materials, and recycling. While not specifically focused on microplastics, it establishes a foundation for addressing waste management more broadly and can indirectly help reduce microplastic pollution by promoting better waste handling practices and recycling methods.

Also, the UNEP has been actively involved in raising awareness and guiding global actions to tackle microplastic pollution. The UNEP's work focuses on promoting international cooperation and policy harmonization, as well as improving scientific understanding of the issue.

In 2016, UNEP released a comprehensive global report on marine litter and microplastics, which offered scientific evidence on the extent of microplastic contamination and its environmental and

health impacts. The report provides guidelines for the prevention and reduction of microplastic pollution in the marine environment, recommending policies and strategies such as banning microplastics in cosmetics, personal care products, and household cleaners and strengthening public awareness and education on the dangers of microplastics and plastic waste.

Both the EU and UNEP frameworks address secondary microplastic pollution through a combination of preventative measures (e.g., reducing plastic waste generation and promoting circular economy models) and mitigation strategies (e.g., improving waste treatment infrastructure, recycling technologies, and product design). Key policy components relevant to secondary microplastic pollution include stronger waste management policies aimed at preventing plastic fragmentation during collection and treatment.

2. WASTE POLICIES IN REPUBLIC OF SERBIA

Serbia's waste management system is governed by a comprehensive set of national laws, regulations, and policies designed to improve waste disposal practices, promote recycling, and mitigate environmental harm. These policies are part of a broader framework aligned with the country's ambitions for European Union (EU) integration. Serbia's efforts to harmonize its legal and regulatory structures with EU standards, particularly in the context of the EU *acquis communautaire* - a body of EU legislation that is binding on member states - reflect the country's commitment to adopting internationally recognized environmental practices. This alignment process has gained momentum following Serbia's signing of the Stabilization and Association Agreement (SAA) with the EU in 2008, which laid the foundation for cooperation in environmental protection and waste management. Serbia's commitment to EU integration underscores its ongoing legal and institutional reforms, particularly in the management of plastic waste and the broader goal of achieving sustainable environmental practices.

One of the cornerstone pieces of legislation in Serbia's waste management framework is the Law on Waste Management (2023). This law serves as the primary national legislation governing waste disposal, recovery, and recycling processes. The law stipulates procedures for the reduction, reuse, and recycling of waste materials, aligning Serbia's practices with EU directives aimed at minimizing waste generation and promoting the circular economy. Moreover, the law emphasizes compliance with EU standards on waste management, such as the Waste Framework Directive and the Packaging

and Packaging Waste Directive, which establish common goals for waste reduction and recycling across EU member states.

In tandem with this legislative framework, Serbia adopted the Waste management program of the Republic of Serbia for the period 2022-2031, a strategic document that sets national objectives for waste reduction, recycling, and overall environmental protection. The program establishes a clear roadmap for achieving higher recycling rates, including specific measures to reduce plastic waste, with a strong emphasis on promoting the circularity of materials. The national plan aligns with the EU's overarching objectives of reducing single-use plastics, increasing recycling rates, and minimizing environmental harm caused by plastic waste. Notably, Serbia's recycling targets for plastic waste are modeled after those set by the EU, aiming for substantial increases in recycling rates and reductions in the volume of plastic waste sent to landfills.

Another significant piece of legislation in Serbia's efforts to address plastic waste is the Law on Packaging and Packaging Waste, which introduces the principle of Extended Producer Responsibility (EPR). Under this law, producers are held accountable for the entire lifecycle of their products, from design to post-consumer waste. This includes the management of plastic packaging waste, which constitutes a major portion of plastic pollution in Serbia. The law mandates that producers take responsibility for the recycling or disposal of packaging waste, either by joining collective recycling schemes or by paying fees that contribute to the proper management of plastic waste. These initiatives align Serbia with the EU's directives, which require member states to enforce producer responsibility for plastic packaging.

Additionally, Serbia has made strides in reducing the consumption of single-use plastic bags, a significant source of plastic waste. Through regulatory measures, including a ban on free distribution of plastic bags in retail environments, Serbia has begun to curb the widespread use of plastic bags, which are a notorious contributor to plastic pollution. These efforts are in line with the EU's Single-Use Plastics Directive (2019), which seeks to reduce the environmental impact of single-use plastic products across member states.

Despite these advancements, plastic waste remains a considerable challenge in Serbia. The country continues to face significant barriers in waste management, primarily due to an underdeveloped waste collection and sorting infrastructure. Although waste separation at the source is encouraged, it is not consistently practiced,

particularly in rural areas, where the infrastructure for separate collection is often inadequate. This lack of comprehensive waste segregation hampers the effectiveness of recycling programs and contributes to the inefficient management of plastic waste.

Furthermore, a substantial portion of Serbia's waste is managed informally, often by waste pickers and through illegal dumpsites, particularly in rural and underserved regions. This informal sector complicates waste management efforts by circumventing official waste disposal channels, thus preventing the proper recycling of plastic materials. The lack of proper waste treatment facilities in these areas exacerbates environmental degradation and poses significant public health risks.

While Serbia has made notable progress in increasing its recycling efforts, the country still heavily relies on landfills for the disposal of waste, including plastic materials. Although landfill diversion strategies are part of the country's long-term waste management plans, the infrastructure for such diversion remains underdeveloped. Modern landfill diversion technologies, such as waste-to-energy systems and composting facilities, have not been widely implemented, which impedes the reduction of waste volumes directed to landfills. The slow adoption of circular economy principles - which emphasize reducing waste, reusing products, and recycling materials - further limits the potential for sustainable waste management practices.

In addition to infrastructure challenges, public awareness and participation in waste management programs remain critical issues. While urban areas have seen some success in promoting recycling practices, rural communities are less engaged in waste segregation efforts, primarily due to limited access to recycling bins and lack of educational campaigns. Consequently, significant volumes of recyclable plastic waste continue to end up in landfills, contributing to the ongoing environmental and ecological challenges posed by plastic pollution.

Serbia also faces challenges in monitoring and enforcement, particularly in relation to the proper implementation of waste management policies. The lack of effective monitoring mechanisms, coupled with inconsistent enforcement of regulations, allows for loopholes in compliance, especially in relation to producer responsibility schemes and the management of packaging waste. Strengthening the oversight of waste management systems and improving the capacity of environmental agencies to monitor plastic waste disposal are essential to achieving the country's long-term waste reduction goals.

To address these challenges, it is imperative that Serbia continues to invest in waste management infrastructure, particularly in rural areas, to ensure that plastic waste is effectively segregated, collected, and recycled. Expanding EPR schemes, improving the coordination of waste management systems, and increasing public education on the environmental impacts of plastic waste are critical to reducing the burden of plastic pollution. Moreover, Serbia must prioritize the implementation of waste diversion technologies and circular economy practices to reduce its reliance on landfills and increase the sustainability of its waste management systems.

3. LEGAL REFORMS FOR PLASTIC WASTE MANAGEMENT IN SERBIA

The primary recommendation concerns the adoption of amendments to the Law on Waste Management. It is essential that plastic waste be recognized as a distinct waste stream within the legal framework. The amended law should establish a comprehensive legal foundation for the development of a by-law that will provide specific regulations on the management of plastic waste, ensuring consistency and clarity in implementation. Recognizing plastic waste as a separate waste stream will enable more targeted regulations, tailored to the specific challenges posed by different types of plastics, thus optimizing waste management efforts. Additionally, such a designation will facilitate the tracking of plastic waste generation and disposal, enabling policymakers to measure progress in the reduction and recycling of plastic materials.

One of the key provisions in this legal framework should address the collection, transportation, and storage of plastic waste. The methods for collecting plastic waste must be designed in such a manner that they prevent the dispersion of microplastics into the environment during transit or storage. Microplastics are highly mobile and can easily become part of the broader environmental system if not carefully contained. Therefore, the legislative framework must mandate the adoption of best practices for the safe and controlled management of plastic waste, especially considering the risk of microplastic contamination. This would include guidelines for the secure sealing of plastic waste containers, regular monitoring of collection routes, and the establishment of dedicated storage facilities equipped to prevent leakage of microplastic particles.

The treatment of plastic waste is one of the primary contributors to microplastic formation. During the treatment process, plastic waste is initially sorted based on material type (e.g., polyethylene terephthalate (PET), polypropylene (PP),

polyethylene (PE), polystyrene (PS), etc.), after which it is washed to remove contaminants. It is at this stage that microplastics can be generated, particularly in the form of fine plastic particles that may be released into wastewater. Given the potential environmental impact, it is of critical importance that each facility engaged in plastic waste treatment possess modern wastewater treatment plants capable of separating and managing microplastic particles. The failure to implement these technologies can result in the uncontrolled release of microplastics into water systems, contributing to the growing pollution of rivers, lakes, and oceans.

Moreover, companies operating such treatment plants should be legally required to ensure that technological wastewater - which results from the washing and processing of plastic materials - undergoes appropriate treatment. This treatment process must focus on the separation of microplastic particles from the effluent. Facilities should be mandated to adopt advanced filtration systems or other technologies capable of removing these minute particles before they are discharged into the environment. Technologies such as membrane filtration, advanced oxidation processes, or sedimentation tanks could be implemented to capture microplastics before the water is released. Furthermore, a legal requirement should be established to ensure that no treatment plant operates without a dedicated technological wastewater treatment system, and that these systems are subject to regulatory oversight through the issuance of a water permit that guarantees compliance with environmental standards. This oversight should be performed by an independent body to ensure transparency and accountability in the wastewater treatment process.

In addition to the treatment of wastewater, the proposed by-law should introduce provisions requiring facilities to manage the residuals that emerge from the waste treatment process. These residuals, often in the form of plastic fines or contaminated sludge, must be handled in accordance with the principles of environmental protection and resource recovery. The by-law should outline clear and enforceable guidelines for the disposal, recycling, or repurposing of these residual materials, ensuring that they do not contribute to further environmental degradation. In particular, plastic fines should be treated as a potential resource rather than waste, encouraging the development of processes for their safe incorporation into new products or their transformation into alternative materials, such as building aggregates or energy sources.

Furthermore, the amended law and the accompanying by-law should mandate regular reporting and

transparency from facilities that handle plastic waste. This would ensure that both governmental agencies and the public are informed about the types and quantities of plastic waste being treated, as well as the effectiveness of the waste treatment and recycling processes. Such transparency will facilitate the identification of bottlenecks or inefficiencies in the waste management system and help optimize the allocation of resources for waste management operations.

In addition to facilitating better waste management practices, the legal framework should also emphasize public engagement and education. Public awareness campaigns on the importance of plastic waste separation, proper disposal, and recycling could contribute significantly to reducing plastic waste at the source. This would foster a culture of responsible plastic use and waste management, particularly if individuals understand the role they play in reducing microplastic pollution. The implementation of extended producer responsibility (EPR) schemes should be accompanied by public outreach programs that encourage consumers to participate in recycling efforts and make informed choices about their plastic consumption.

One critical aspect of the proposed legal changes is ensuring the enforcement of compliance with the amended laws. The government must allocate sufficient resources to environmental inspection agencies, enabling them to conduct regular audits of plastic waste treatment plants and facilities involved in the recycling process. Failure to comply with the updated regulations should result in severe penalties, including fines, mandatory closures, or the suspension of operations for repeat offenders. The robust enforcement of these regulations will be essential for ensuring that facilities adhere to the environmental standards necessary for mitigating microplastic pollution.

Finally, the development of innovation in alternative materials and technologies should be actively promoted through the amended waste management framework. Incentives could be offered to companies that invest in biodegradable or non-toxic alternatives to conventional plastics, as well as in the development of more efficient recycling technologies. Additionally, the legal framework should encourage the implementation of circular economy principles, where plastic products are designed with their end-of-life disposal in mind. Products designed for ease of recycling and resource recovery would reduce the amount of plastic waste generated and help minimize the creation of microplastics during waste processing.

CONCLUSION

The EU's directives and UNEP's guidelines provide a robust framework for addressing both primary and secondary microplastic pollution through regulatory measures, public-private collaboration, and a focus on lifecycle management. While EU regulations are highly targeted to specific sectors (such as cosmetics and plastics manufacturing), UNEP's global approach emphasizes coordination across borders and sectors to tackle microplastic pollution comprehensively. Both frameworks highlight the importance of integrated policies that combine prevention, innovation, and sustainable waste management to reduce the environmental and human health impacts of microplastics.

Serbia is making significant strides toward improving its waste management policies, particularly with regard to plastic waste. The country has adopted key legal frameworks, including the Law on Waste Management and the National Waste Management Program, that are aimed at reducing plastic waste and improving recycling rates. However, challenges such as inadequate waste sorting infrastructure, informal waste management systems, and public awareness must be addressed for Serbia to effectively tackle plastic pollution. Continued efforts to align with EU directives and invest in recycling technologies, combined with enhanced public education and industry collaboration, are essential for achieving long-term sustainability in plastic waste management.

Where competent authorities prescribe specific, legally binding conditions within the permitting framework - particularly concerning the segregation of plastic waste, mandatory pre-treatment procedures, storage and treatment standards, and wastewater management requirements - combined with provisions ensuring procedural transparency and public access to environmental information, it is foreseeable that such regulatory measures will

contribute to the progressive reduction of microplastic pollution.

In conclusion, the adoption of amendments to the Law on Waste Management, alongside the establishment of a supporting by-law, is crucial for improving the management of plastic waste and preventing the proliferation of microplastic pollution. The implementation of these regulatory measures will provide the necessary legal infrastructure to ensure that Serbia's waste management practices align with contemporary environmental standards and contribute to global efforts in tackling plastic pollution. By addressing critical issues such as plastic waste collection, treatment, and residual management, as well as enhancing transparency and public participation, Serbia can significantly reduce its contribution to microplastic pollution and move towards a more sustainable, circular economy model. This integrated approach will not only benefit Serbia's environment but also enhance its reputation on the global stage as a responsible actor in the fight against plastic pollution.

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