Research Journal of Agricultural Science, 58 (3), 2026; ISSN: 2668-926X;

http://doi.org/10.59463/RJAS.2026.3.10

PREVENTION OF ENVIRONMENTAL POLLUTION RESULTING FROM WASTE GENERATION AND MANAGEMENT IN ROMANIA

Larisa-Salomea CIORTAN[1], Livia-Andreea CIOABĂ[1], N. BĂGHINĂ[1]

[1] University of Life Sciences "King Mihai I" in Timișoara, 300645, Romania

Corresponding author: narcis_baghina@usvt.ro

Abstract: *This paper analyzes the structural dynamics of waste management in Romania, evaluating the interdependence between the volume of waste generated, the efficiency of existing infrastructure, and pollution prevention strategies. Based on data from Eurostat and the National Environmental Protection Agency (ANPM), the study highlights an upward trend in per capita municipal waste generation between 2016 and 2023—a development that intensifies anthropogenic pressure on national ecosystems. An assessment of treatment systems reveals a critical reliance on a linear economic model: over 74% of waste is disposed of in landfills. This method leads to severe secondary pollution, including soil contamination via leachate and the emission of greenhouse gases—risks exacerbated by the fact that the biodegradable fraction accounts for the majority (~49.2%) of the waste composition by weight and undergoes fermentation due to a lack of industrial composting facilities. As a structural reform measure, the paper examines the impact of implementing the Deposit-Return System (DRS) during the 2024–2026 period. The analysis demonstrates how the use of a direct economic incentive has altered consumer behavior, facilitating the diversion of waste from landfills and enabling the separate collection of over 82% of primary packaging (plastic, metal, and glass). Effective pollution prevention in Romania requires moving away from "end-of-pipe" remediation solutions in favor of a circular economy. Optimizing the traceability of materials at the source, applying the "pay-as-you-throw" principle, expanding the infrastructure for Integrated Waste Management Systems (IWMS), and strengthening ongoing environmental education are essential.*

Keywords: *waste management, circular economy, Deposit-Return System (DRS), landfilling, IWMS.*

INTRODUCTION

In the current context, marked by accelerated urbanization and an ever-growing consumer culture, the issue of waste has ceased to be merely an administrative matter; it has become one of the greatest ecological challenges of our generation. For Romania, this reality is all the more apparent given that, while society has developed rapidly over the last few decades, the infrastructure for waste collection and recycling has often lagged behind. The pollution of soil, waterways, and the air—resulting from the inadequate management of waste—serves as a warning sign that we can no longer afford to ignore.

As future professionals, I believe it is essential to view this issue through the lens of the circular economy—a regenerative model that seeks to fundamentally shift the traditional "buy, use, and discard" logic. The transition toward an economy in which waste is transformed into secondary raw materials is no longer just a legal obligation mandated by European Union directives; it is a moral and ecological necessity for ensuring a sustainable future.

Although Romania's legal framework has been modernized, practical implementation at the local community level still faces numerous obstacles—ranging from a lack of modern sorting

facilities to cultural resistance regarding the selective sorting of waste within households. In this paper, I aim to analyze how these shortcomings affect environmental factors in our country and to explore concrete solutions through which we can transform waste from a major source of pollution into a valuable economic resource.

MATERIALS AND METHODS

The methodology applied in this paper was specifically designed to analyze the interdependence between the three central elements mentioned in the title: waste generation, the efficiency of waste management, and solutions for preventing environmental pollution in Romania.

The research relied on the following specific materials and methods:

- **Materials used for the analysis of waste GENERATION:**

To assess the volume and typology of waste generated within the country, I utilized statistical datasets from the national reports of the National Environmental Protection Agency (ANPM), as well as European indicators from Eurostat. These materials enabled me to identify the primary sources of waste (household, commercial, and industrial) and the trends in per capita waste quantities over recent years.

- **Methods for evaluating current WASTE MANAGEMENT:**

I employed a comparative analysis to assess how waste collected in Romania is handled (landfilling, sorting, recycling, composting) in relation to the mandatory targets established by legislation (Emergency Ordinance 92/2021). Furthermore, I conducted a case study based on monitoring data from the RetuRO system, evaluating the effectiveness of the Deposit-Return System (DRS) as a novel, direct method for managing packaging waste.

- **Analytical methods for the PREVENTION OF ENVIRONMENTAL POLLUTION:**

Drawing on specialized scientific literature, I applied a qualitative synthesis method to map environmental risks. We analyzed how optimizing the links in the waste management chain can prevent soil and groundwater contamination by leachate, as well as reduce methane and CO_2 emissions from landfills.

RESULTS AND DISCUSSION

An integrated analysis of quantitative and qualitative indicators reveals a significant discrepancy between waste generation trends and the technical capacity to neutralize environmental risks within Romania.

Municipal waste generation and composition analysis by fraction

The quantitative assessment of waste generation indicates an upward trend at the national level over the last decade. To ensure rigorous monitoring of the volumes generated per capita, official data from Eurostat have been extracted and summarized in the visual representation below:

Research Journal of Agricultural Science, 58 (3), 2026; ISSN: 2668-926X;
http://doi.org/10.59463/RJAS.2026.3.10



Figure 1. Trend in the amount of municipal waste generated in Romania per capita (2016–2023).

The trend analysis presented in Figure 1 shows a steady increase in the amount of waste produced per capita in Romania. The volume has risen from approximately 260 kg/inhabitant in 2016 to over 300 kg/inhabitant in 2023. This upward trajectory directly reflects the growth in the population's purchasing power and a preference for over-packaged products.

Although the official figure remains below the European Union average (~517 kg/inhabitant), the reality masks significant under-reporting, stemming from the lack of integration of rural areas into waste collection networks. From the perspective of environmental pollution prevention, this graph serves as a warning sign: the anthropogenic pressure on collection systems is continuously mounting, making the optimization of waste management an absolute national priority.

To understand the inherent pollution potential associated with these rising quantities, it is essential to examine the physical composition of mixed municipal waste generated nationwide, as illustrated in Figure 2:

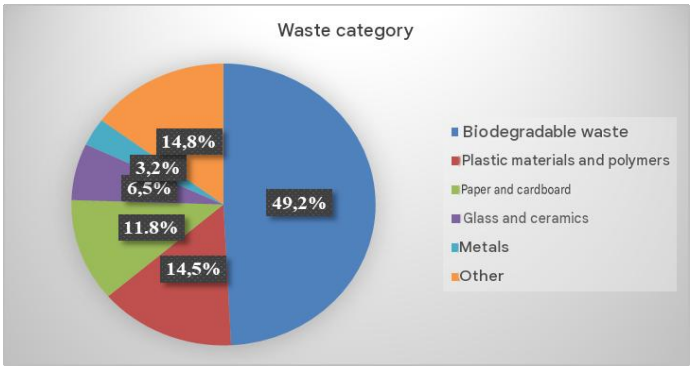


Figure 2. Average gravimetric composition of municipal waste generated in Romania

The structural analysis illustrated in Figure 2 demonstrates that the biodegradable fraction accounts for half of the total mass of waste generated in Romania (~49.2%). In the absence of separate collection, this predominant organic component constitutes the primary environmental risk factor, as its decomposition directly generates greenhouse gases and volatile toxic compounds. Furthermore, the high proportion of plastics (14.5%) points to consumption patterns centered on single-use packaging, underscoring the urgent need to implement effective mechanisms for capturing synthetic polymers at the source to prevent their persistent dispersal into soil and water.

Waste Management and Analysis of Gaps Relative to EU Targets

Waste treatment in Romania reflects the persistent dominance of a linear economic model. An analysis of waste flows reveals that landfilling remains the default management method, completely disregarding the statutory waste hierarchy. A detailed overview of current management performance, measured against established environmental obligations, is presented in Table 1:

Table 1

Waste Management Indicators in Romania vs. European Targets

Technical Performance Indicator	Current Value for Romania	Mandatory European Target	Gap Relative to Targets
Overall Municipal Recycling Rate	**13,7%**	55,0%	**-41,3%** (High risk of infringement proceedings)
Landfill Disposal Rate	**74,3%**	< 10,0% (by 2035)	**+64,3%** (Overcapacity of landfills)
Overall Packaging Recycling Rate	**38,3%**	65,0%	**-26,7%** (Major collection deficiencies)

The consolidation of the indicators in Table 1 highlights a severe structural deficit within the Romanian system. The substantial deviation of +64.3% recorded in the landfilling segment indicates that the national infrastructure is geared almost exclusively toward the long-term storage of waste, while neglecting environmentally sound treatment. The critical gap—exceeding 41 percentage points—relative to the municipal recycling target exposes Romania to the imminent risk of financial sanctions from the European Union.

To visualize the disparity between the current situation and the required environmental compliance profile, the following chart illustrating the distribution of the main waste streams is presented:

Research Journal of Agricultural Science, 58 (3), 2026; ISSN: 2668-926X;
http://doi.org/10.59463/RJAS.2026.3.10

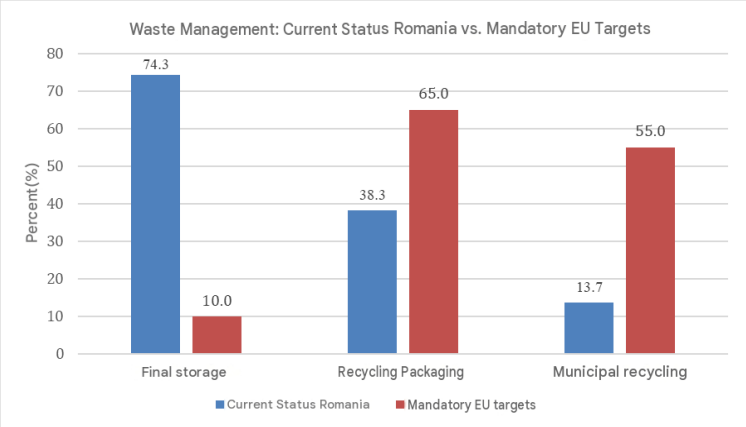


Figure 3. Distribution of main treatment streams: Current national status vs. Mandatory EU targets (%).

The comparative view provided in Figure 3 reveals a mirror image—one that is entirely inverted—of environmental priorities: while European standards mandate a minimum threshold (less than 10% for landfilling), Romania shows the opposite, with the vast majority (74.3%) ending up in landfills; conversely, in areas where high performance is required (recycling), the domestic system falls short. This graphical representation demonstrates that the mere existence of a legal framework is insufficient without massive investment in modern sorting facilities capable of reversing the proportions shown in the statistical bars.

To pinpoint the source of the bottlenecks within the packaging waste management chain, Table 2 breaks down recycling rates by material type:

Table 2

Sectoral recycling rates for packaging waste by material type

Packaging Material	Recorded Recycling Rate	National / European Target	Efficiency Assessment by Segment
Paper and Cardboard	**67,88%**	60,0%	Performance in compliance; increased traceability in the commercial sector.
Plastic (PET and mixed polymers)	**31,59%**	50,0%	Subpar; extremely vulnerable to dispersal into the natural environment.
Glass	**42,10%**	70,0%	Significant decline due to a lack of local infrastructure.

Aluminum and Metals	**51,20%**	50,0%	At the threshold of compliance; supported by intrinsic economic value.

The analytical data in Table 2 demonstrate that the success of waste management is closely linked to the secondary economic value of the materials. The paper and cardboard segment exceeds the European target by more than 7 percent, thanks to well-controlled industrial commercial flows. In contrast, materials with more complex and costly collection logistics—such as glass (a shortfall of 27.9%) and plastic (a shortfall of 18.41%)—reflect a lack of accessible collection points for citizens.

Figure 4 provides a comparative overview of how each material category approaches or deviates from the threshold for legal compliance:

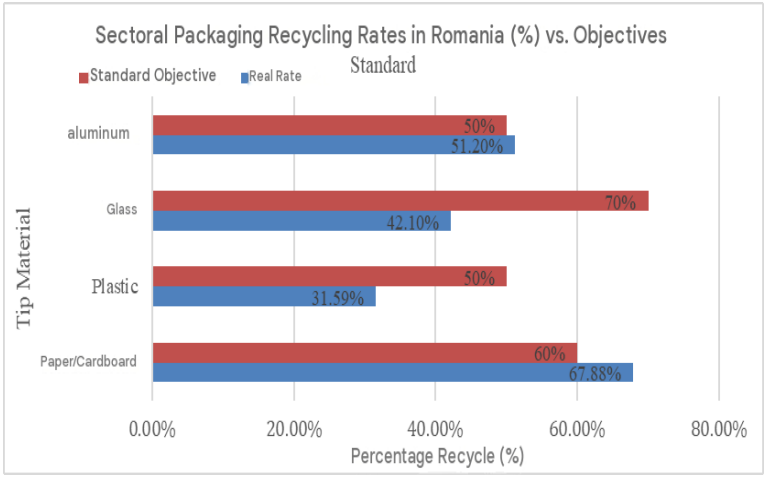


Figure 4. Actual sectoral packaging recycling rates in relation to standard targets (%).

The linear representation in Figure 4 provides a visual confirmation of the performance disparities among different packaging categories. It is clearly evident that the bar corresponding to plastic remains stagnant at a critical level—well below the compliance threshold—which explains the pervasive presence of discarded polymer packaging in the natural environment. This visible shortfall provides a technical justification for why it became imperative to introduce a dedicated system, such as the Deposit-Return System (DRS), designed to drive an artificial increase in recovery rates through financial incentives and direct rewards for consumers.

Discussions on Environmental Pollution Prevention

The data presented confirm a direct correlation between the quality of secondary waste management and the degradation of environmental factors in Romania.

The data presented confirm a direct correlation between the quality of secondary waste management and the degradation of environmental factors in Romania. To counteract soil pollution

caused by leachate and air pollution resulting from landfill gas emissions (methane), national strategies have shifted from punitive measures toward economic incentive mechanisms applied at the source.

The effectiveness of these instruments is demonstrated by the implementation progress of the Deposit-Return System (DRS)—managed by RetuRO—with official collection rates from recent years reflected in the graph below:

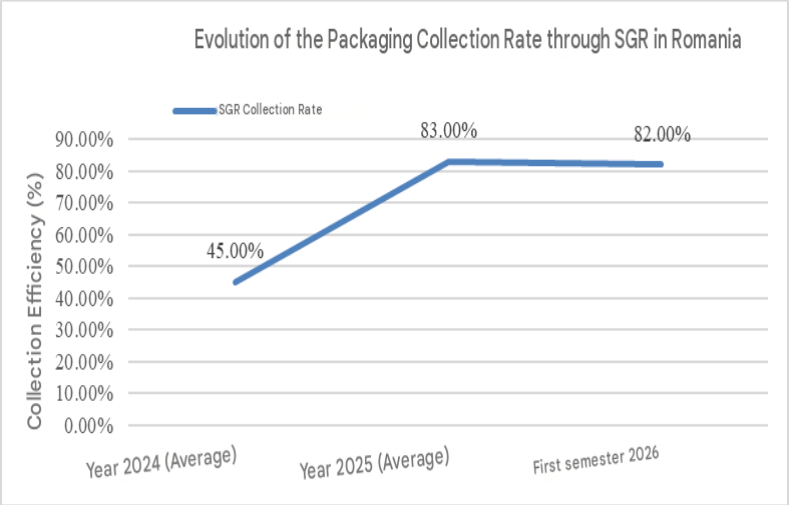


Figure 5. Evolution of official packaging collection rates via the Deposit-Return System (DRS) in Romania (%)

The upward trajectory documented in Figure 5 technically confirms a fundamental hypothesis of this study: pollution prevention is not effectively achieved through end-of-pipe remediation technologies, but rather through digitalization and the prioritization of direct material traceability. The rapid transition from an initial collection rate in 2024 to a robust, consistent level—83% in 2025 and 82% in the first half of 2026—demonstrates that the implementation of a direct economic incentive (the deposit scheme) resulted in the immediate diversion of over 5.2 billion packaging units (PET, aluminum, glass) from landfill disposal. From an ecological perspective, these volumes represent thousands of tons of polymers that have been entirely removed from Romania's aquatic and forest ecosystems and routed directly to secondary recycling facilities.

CONCLUSIONS

An integrated analysis of environmental indicators, statistical data, and operational dynamics in the field reveals that preventing environmental pollution caused by waste generation and management in Romania is an ecological and strategic priority of critical importance. Correlating longitudinal data provided by Eurostat with domestic administrative realities highlights a systemic

vulnerability: although, statistically, the gross volume of waste generated per capita places Romania below the European average, the steady upward trend recorded between 2016 and 2023 (from 260 kg to over 305 kg per inhabitant annually) indicates an ever-increasing anthropogenic pressure on environmental components.

The historical failure of municipal waste management is directly reflected in the exceptionally high rate of landfilling (~74.3%)—a figure that completely contradicts the principles of the European waste hierarchy. From an ecological perspective, this reliance on non-compliant landfills transforms waste management from a logistical process into a major source of severe secondary pollution. The degradation of the dominant organic fraction (which accounts for 49.2% of the national waste composition by weight) acts as a destructive, two-fold vector: on land, it generates chemical leachate that contaminates the soil and groundwater; in the atmosphere, it leads to massive emissions of methane (CH_4) and other greenhouse gases, further exacerbated by uncontrolled, illegal burning.

Nevertheless, the spectacular logistical success of the Deposit-Return System (DRS)—which saw packaging collection rates climb rapidly from its inception to a robust, consistent level of over 82–83% during the 2025–2026 period—demonstrates the viability of strategies based on direct economic incentives. The DRS confirms a core hypothesis of this work: pollution prevention cannot be effectively achieved through "end-of-pipe" remediation technologies applied at the end of a product's life cycle; rather, it requires the isolation, sorting, and strict traceability of material flows directly at the source, thereby preventing recyclable resources from becoming environmental contaminants.

To achieve ecological neutrality and avoid imminent European sanctions, Romania must implement coordinated strategies focused on the urgent operationalization of Integrated Waste Management Systems (IWMS) through modern sorting and composting facilities. This includes extending the logistical principles of the DRS—as well as the "pay-as-you-throw" differential pricing model—to other municipal waste streams, alongside the institutionalization of environmental education campaigns in schools and local communities to overcome cultural resistance toward selective waste collection.

BIBLIOGRAPHY:

ANDREI WEHRY, MIRCEA ORLESCU – Recycling and Ecological Landfilling of Waste, Orizonturi Universitare Publishing House, 2000.

CIOCOIU, C. N., COLESCA, S. E., & POPESCU, R. (2024) – Analysis of the Efficiency of Integrated Waste Management Systems in Romania's Development Regions, in *Journal of Management and Economic Engineering*, Vol. 23, No. 1, pp. 112–126.

GILDA DIANA BUZATU, ELENA GAVRILESCU – Waste Management, Sitech Publishing House, Craiova, 2014.

GOLESCU, M. (2020) – The Circular Economy: An Opportunity for Romania's Sustainable Development, in Journal of Management and Economic Engineering, Vol. 19, No. 2, pp. 45–58. 10.Ministry of Environment, Waters and Forests (2017) – National Waste Management Plan (NWMP), approved by Government Decision no. 942/2017, Bucharest.

IONESCU, V., & MARINESCU, C. (2025) – Biodegradable Waste Management in Romania: Climate Risks, Methane Emissions, and Industrial Composting Solutions, Technical Publishing House, Bucharest.

POPESCU, M., & IONESCU, A. (2023) – Life Cycle Analysis of Materials and Integrated Municipal Waste Management, Editura Universitară, Bucharest.

ROJANSCHI, V., BRAN, F., & DIACONU, G. (2008) – Environmental Protection and Engineering, Editura Economică, Bucharest.

*** European Circular Economy Stakeholder Platform (2025) – *Circular Economy in Romania:* Post-Implementation Assessment of Economic Incentives *and Waste Diversion from Landfills*, European Commission, Brussels.

*** European Environment Agency (EEA) (2025) – Country Profile on Waste Prevention and Management: Romania, Copenhagen.

*** European Parliament and Council of the European Union (2018) – Directive (EU) 2018/851 amending Directive 2008/98/EC on waste, Official Journal of the European Union, L 150/109.

*** Eurostat (2026) – Database: Waste generation and treatment (env_wasmun) – Municipal waste statistics per capita, European Commission.

*** Government Emergency Ordinance no. 92/2021 on the waste regime, published in the Official Gazette of Romania, Part I, no. 817/2021.

*** National Agency for Environmental Protection (ANPM) (2025) – National Report on the State of the Environment in Romania, Chapter 8: Waste Management, Ministry of Environment, Waters and Forests, Bucharest.

*** RetuRO Sgr (2025) – Annual Performance and Sustainability Reports on the Management of Non-Reusable Primary Packaging in Romania, Bucharest.

*** Returo Sgr S.A. (2026) – Bi-annual Operational Report: Monitoring Collection Rates and the Evolution of Consumer Behavior between January and June 2026, Bucharest.