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PhD Thesis Summary

MICROPLASTIC POLLUTION: RISKS TO HEALTH, THE ENVIRONMENT, THE ECONOMY, AND PUBLIC PERCEPTIONS IN ROMANIA

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Table of Contents

1. Introduction	4
1.1. Research Questions	7
1.2. Study Objectives	8
1.3. Context and Significance of the Study	9
1.4. Structure of the Thesis	9
1.5. Methodological Framework of the Research	11
2. Results.....	13
2.1. Bibliometric Analysis.....	13
2.2. Strategies for Reducing Microplastic Pollution	14
2.3. Analysis of Perceptions Regarding Microplastic Particles Based on Applied Surveys	14
2.3.1. Socio-demographic Characteristics of the Sample	14
2.3.2. Synthesizing Public Perceptions on Microplastic Pollution: Comparative Results from Applied Research	17
3. Final Analysis and Impact of the Research	20
3.1. Synthesis of Research Results on Microplastic Particles	20
3.2. Methodological Limitations	21
3.3. Personal Contributions	22
3.4. Answer to the Research Questions.....	23
3.5. Future Perspectives	24
3.6. Dissemination of Results	25
References	29
Appendices	37

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1. Introduction

For many decades, plastic pollution has been a global environmental issue. As this material degrades, small plastic fragments end up invading ecosystems and entering the food chain, according to the World Health Organization (WHO) (2019a). Plastic particles smaller than 5 millimeters (MPs) (Barnes et al., 2009) have become a major concern, primarily for public health and secondarily for the environment. According to a WHO report (2019b), MPs are found in food (Snekkevik et al., 2024; Kumar et al., 2024), drinking water (Capozzi et al., 2018; Ermolin et al., 2024; Ma et al., 2016), and air (Chen et al., 2024), which means that people can ingest or inhale them daily. The WHO emphasizes that, although the effects on human health are not yet fully understood, there is potential for MPs to cause inflammation (Cao et al., 2023) and oxidative stress in the body. These processes are linked to the respiratory (Huang et al., 2024) and cardiovascular infections (Xiao et al., 2024); however, further research is needed to clarify exactly how these particles affect the human body. As mentioned in a report published by WHO (2022), on average, a person may ingest between 39,000 and 52,000 MPs per year through their daily diet. However, this estimate can vary depending on dietary habits. For bottled water consumers (Mansoori et al., 2025), exposure is even higher. Research suggests that a person who drinks only bottled water may consume approximately 22 times more MPs compared to those who drink tap water (Mason et al., 2016). Besides food intake, another significant source of exposure is air. A study by Cox (2019) estimated that an adult may inhale around 74,000 MPs per year. Exposure is higher in urban areas and indoor spaces, where MPs from synthetic fabrics and other sources are more abundant (Dris et al., 2017). An analysis conducted by Barceló (2023) supports that MPs are also found in human blood (Liu et al., 2024) and feces, indicating that some of the ingested or inhaled MPs may remain in the body for a certain period. Another concerning aspect related to human health is the possibility that MPs may contain or transport toxic chemicals such as phthalates and bisphenol A (BPA), which can negatively affect the endocrine system. These substances are known as hormone disruptors and can impact development, metabolism, and reproductive functions. The WHO and other organizations warn that prolonged exposure to these compounds may increase the risk of health problems, particularly in children and adolescents, who are more susceptible to these influences (OMS, 2019a).

MPs, increasingly omnipresent in the environment, have been found in oceans, rivers, soils, and even in urban air. The United Nations Environment Programme (UNEP) (2019) warns that MPs pose a threat to biodiversity and the balance of ecosystems. Especially in marine environments, they are ingested by fish, birds, and other organisms, affecting their health and, consequently, the safety of the food chain. Since many of these animals are part of the human diet, MPs pollution has indirect effects on human health and well-being (PNUM, 2021). A major issue in the natural environment is that MPs are non-biodegradable and persist in the long term, contributing to the degradation of soil and water quality. This disrupts ecosystems' natural regenerative capacities and impacts the health of organisms living in these habitats (PNUM, 2023a). One example is soil contaminated with MPs, which over time affects plants' ability to grow, reduces agricultural productivity, and ultimately can impact global food security (OMS, 2019a). These problems are being studied more intensively worldwide, particularly in marine ecosystems (GESAMP, 2024). A key risk is that aquatic organisms may mistake MPs for food. According to WHO (2022), their presence in the bodies of these organisms can lead to malnutrition, reproductive issues, and increased mortality among fish and bird populations. Thus, the impact of MPs spreads throughout the food chain, affecting the stability of ecosystems (PNUM, 2021).

According to a UNEP report (2023b), global plastic production has increased significantly in recent years, from 2 million tonnes in the 1950s to over 40 million tonnes in 2023. A large portion of this plastic, over 11 million tonnes annually, reaches the oceans from soil, surface water, and groundwater sources. This type of MPs pollution has a cumulative effect, as MPs gradually break down and persist in the environment over long periods, leading to increased risk and growing exposure for the population over time. At the same time, international and European organizations have adopted important measures to reduce the risk of plastic pollution, implementing regulations and developing partnerships that promote sustainable practices and, importantly, the reduction of plastic consumption. From clear directives banning certain plastic products to global treaties on waste management, these organizations collaborate with governments and the private sector to mitigate the environmental impact of plastic. Below are some major initiatives: (i) The European Union (EU) Single-Use Plastics Directive, adopted in 2019, aims to reduce marine pollution by banning specific single-use plastic products such as straws, cutlery, and plates (CE, 2019). This directive imposes various requirements on EU member states, including measures for recycling, waste collection, and the development of sustainable alternatives. (ii) Another initiative is the "Plastic Amendment", which enforces much stricter controls on the international trade of

plastic waste, aiming to prevent the export of hazardous waste to developing countries that cannot manage it properly (Secretariatul Convenției de la Basel, 2024). (iii) Under UNEP, the Global Partnership on Plastic Waste aims to support governments in better managing and reducing plastic waste, while also encouraging the adoption of a global circular economy (PNUM, 2023b). This initiative promotes international collaboration to enable the safer and easier development of sustainable solutions and recycling technologies, while contributing to reducing plastic consumption and minimizing the impact on marine ecosystems. (iv) The United Nations (UN) Resolution for a Global Plastic Treaty addresses the issue at its source, aiming for the negotiation of a binding global treaty to combat plastic pollution. The goal of this treaty is to establish international standards for reducing plastic production, from manufacturing and consumption to disposal-thus promoting global solutions to the plastic crisis (ONU, 2022). Nonetheless, plastic pollution remains a growing global issue (Stoett et al., 2024).

The creation of these pollutants, such as MPs and nanoplastics (NPs), is driven by several factors, including the ongoing production and excessive use of single-use plastics, inadequate waste management in some parts of the world, and, not least, the lack of efficient recycling infrastructure. These tiny plastic particles-resulting from the degradation of larger plastic products or released directly into the environment extremely persistent and, once discharged into the environment, they accumulate in soil, water, and air, and are difficult to remove (Dayal et al., 2024; Wang et al., 2021; Zhang et al., 2024). Although MPs are considered a formidable pollutant that raises significant global concerns (Ihenetu et al., 2024), some voices in the research community argue that their long-term effects may not be as devastating as often portrayed. This debate, thoughtfully discussed by Backhaus & Wagner (2020) places the low-risk camp (Burton & Cervi, 2019) on one side, and on the opposite side, the high-risk camp emphasizing major threats to the environment and human health (Rochman et al., 2015). From this contrast, it becomes clear that MPs deserve our attention, as they shed light on how science frames environmental risks-in this case, pollution caused by MPs.

In the international context, according to Gao (2024), reducing MPs pollution has become a priority, and various methodologies are currently being developed to limit their impact and associated environmental and health risks. Among the main approaches is the improvement of filtration systems in wastewater treatment plants (Bawa et al., 2024), designed to capture MPs before they reach water sources. Increasing emphasis is also being placed on the development of biodegradable and compostable materials (Nizamuddin et al., 2024) as alternatives to conventional plastics to reduce the sources of MPs. Another important aspect involves public education and awareness initiatives (Kramm et al., 2022), which encourage

reduced use of plastic products and support selective waste collection (Mihai et al., 2021). To address the complexity of MPs pollution, the present study employs a series of quantitative, qualitative, and mixed methodologies-including questionnaires, descriptive statistical analyses, statistical regressions, perceptual analyses, and narrative approaches-to highlight public awareness levels, influential demographic factors, dominant media narratives, as well as respondents' emotional and behavioral responses to perceived risks. In addition, the bibliographic analysis provides a solid theoretical foundation and emphasizes existing research gaps in previous studies on MPs pollution.

1.1. Research Questions

This thesis is structured around three main research questions, each addressing a complementary dimension of the MPs issue: from characterizing the existing scientific discourse and conducting a bibliometric analysis of academic production, to exploring public perceptions of the associated risks and the influence exerted by media narratives.

- RQ1. To what extent does the current scientific literature reflect the issue of plastic and MPs pollution in Romania?
- RQ2. What are the general trends in the perception and awareness of MPs among the Romanian population, how do these influence the perception of economic, social, health, and environmental risks, and what implications can be identified for the development of educational and sustainable initiatives in managing MPs pollution?
- RQ3. How does exposure to media narratives about MPs influence the perception of health and environmental risks among the Romanian population?

1.2. Study Objectives

General Objective

To conduct an integrated analysis of the issue of MPs pollution in Romania by examining the specialized literature and bibliometric trends, investigating public perception of risks, economic, social, and environmental impacts, including the influence of media narratives-to establish future research directions and sustainable measures within the context of the transition to a circular economy.

Specific Objectives

- **O1.** Analyze the specialized literature on the effects of MPs pollution to identify current knowledge gaps and outline future relevant research directions for both the Romanian and international contexts.
- **O2.** Perform a bibliometric analysis to evaluate how the issue of plastic and MPs pollution is addressed in Romania and to identify research directions relevant to the circular economy, complemented by a qualitative analysis of current policies and strategies for managing MPs in freshwater and soil, based on international specialized literature.
- **O3.** Explore the level of awareness and perception of the Romanian public regarding MPs and their impact on the environment and health.
- **O4.** Assess the economic, social, and perceptual impact of soil pollution with MPs in Romania to identify relationships between perceived costs, social issues, and negative effects on the community.
- **O5.** Analyze the risks perceived by the Romanian public related to exposure to MPs by evaluating the perceived probability and impact on health, environment, and economy.
- **O6.** Evaluate the influence of media narratives on the awareness and perception of health and environmental risks associated with MPs among the Romanian population.

1.3. Context and Significance of the Study

The title of this work reflects the importance and timeliness of the addressed topic within a global context increasingly marked by evident ecological crises. Pollution with MPs is recognized as an emerging problem with major effects on the environment and human health (AEPC, 2018; OMS, 2024). According to Dhivert (2024), this form of pollution is fueled by multiple sources, such as industrial activities, intensive agricultural practices, and inadequate waste management (Kim et al., 2025). At the international level, the phenomenon is intensively studied (Garai et al., 2024), yet in Romania, research remains fragmented, and public understanding of the associated risks is still limited (Mihai et al., 2021).

This research addresses the issue of MPs from an integrated perspective through a series of complementary studies. The first two analyses explore the dynamics of research and the market related to MPs, using bibliometric and sectoral analysis methods, aiming to establish emerging directions and existing challenges. Subsequently, four distinct studies investigate the perception of the Romanian public regarding the risks and solutions associated with MPs pollution, providing a detailed picture of the level of awareness and the influence of mass media in shaping attitudes. Through this interdisciplinary approach, which combines literature analysis, perception evaluation, and assessment of economic, social, and ecological impacts, the thesis contributes to an in-depth and contextualized understanding of MPs pollution in Romania. The study not only provides theoretical and empirical clarifications but also offers useful directions for developing effective public policies, awareness measures, and sustainable strategies to reduce the impact of this emerging type of pollution.

1.4. Structure of the Thesis

This thesis addresses the emerging issue of MPs pollution in Romania from an integrated and multidisciplinary perspective, encompassing ecological, social, economic, and public perception dimensions. The paper is structured into four main sections (Figure 1), comprising five chapters, each contributing to the advancement of knowledge regarding the impact of MPs on the environment and society, as well as to the development of solutions tailored to the Romanian context.

The first section, Chapter 1, includes a general introduction. This introductory chapter outlines the major directions of the research, establishing the general context of the MPs pollution issue, the overall and specific objectives of the study, as well as the research questions.

It highlights the relevance of this topic for public health, the environment, and sustainability policies.

The second section, Chapter 2, presents a specific literature review. This section provides a comprehensive overview of both international and national literature on MPs: definitions, classifications, sources, and global trends in plastic and MPs pollution. It analyzes international monitoring standards, health and environmental effects, prevention strategies through the circular economy, and human vulnerabilities. A SWOT analysis of the relevant literature is also included, outlining the existing research gaps

The third section (Chapter 3 - Chapter 4) includes case studies conducted during the research period. Chapter 3 focuses on an in-depth bibliometric analysis based on data from the Web of Science and Scopus databases, aimed at evaluating the coverage of peer-reviewed literature on plastic waste in Romania. In this study, to which I contributed as a co-author, alongside the bibliometric analysis, a thematic review is presented of the main areas related to waste management, plastic and MPs pollution, and, ultimately, mitigation options. Following the market analysis, *Chapter 4* includes four perception-based case studies. The first study examines general perceptions of the risks associated with MPs, based on a dataset featured in an article accepted for publication. This study investigates how the public perceives the potential effects of MPs on health, the environment, and other relevant dimensions. The second study assesses the economic and social impacts of soil pollution with MPs and makes an innovative contribution by evaluating public perception regarding this type of pollution, an underexplored topic so far. With the permission of Springer Nature, the following study uses data from a sample of 569 individuals, revealing high economic costs, significant social concerns, and a high perceived likelihood of negative impact. Statistical correlations between these dimensions reveal a strong interdependence between economic and social perceptions and underscore the need for integrated policy interventions (Pop et al., 2025). Another case study, currently under review, based on risk perception related to human exposure to MPs, analyzes public views on the various risks associated with MPs (economic, health-related, and ecological). Preliminary results indicate a high level of perceived risk, particularly regarding human health and the environment. Significant differences were also observed between urban and rural areas in how these risks are perceived. The final study in Chapter 4, related to MPs perception, focuses on the role of *media narratives* and investigates how media influence public awareness and perception in Romania. Based on the conducted survey and the obtained results, binary logistic regression confirmed the determining role of media narratives and age in shaping perceptions about health and environmental risks (Pop et al., 2023).

The fourth section includes Chapter 5, which provides a synthesis of the research findings, the methodological limitations encountered throughout the process, personal contributions, future perspectives, and, last but not least, the dissemination of results from the entire doctoral period.

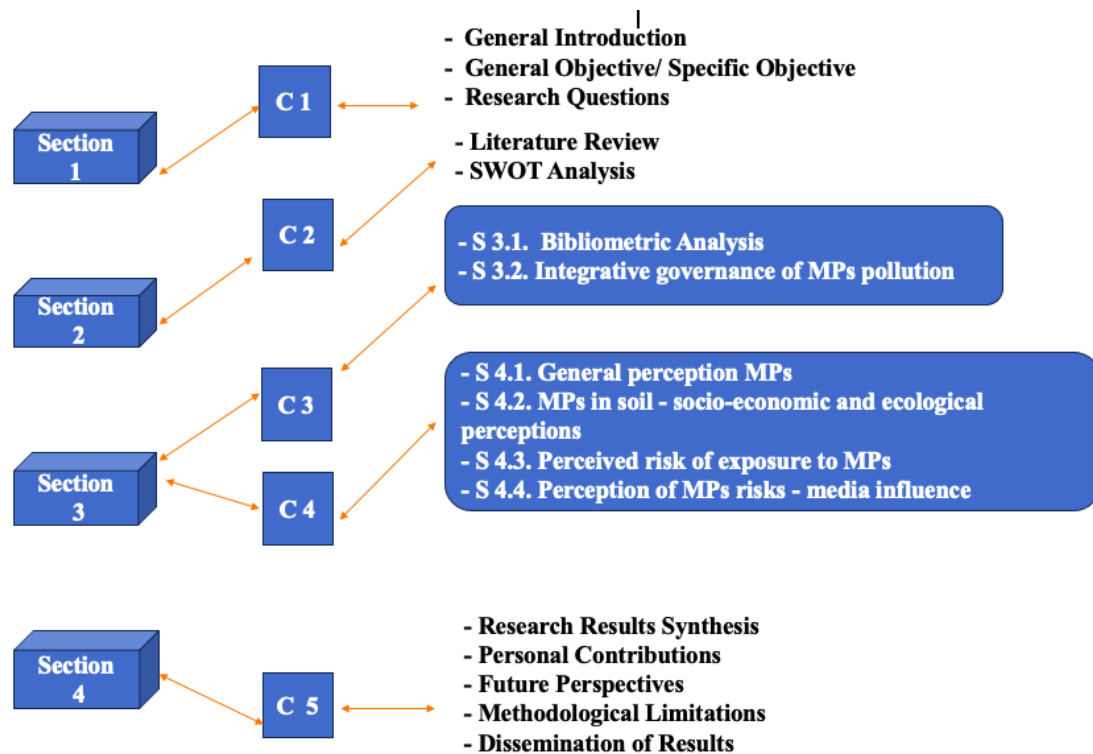


Figure 1. Thesis Structure

Note: C - Chapter; S - Case Study

1.5. Methodological Framework of the Research

Given the structure of the thesis presented above, the research dedicated to the MPs issue was organized around distinct case studies, each with a specific methodological approach, adapted to the objectives and type of analysis proposed. The first case study used a bibliometric analysis, based on systematic queries in international scientific databases, to outline global research trends on MPs and identify knowledge gaps. The second study was built on the basis of an interdisciplinary thematic review of academic sources and the current legislative framework, focusing on the impact of MPs in soil and freshwater and their integration into environmental policies. The studies in chapter 4 were developed through mixed research,

predominantly quantitative, but also with a qualitative component, based on questionnaires applied at the national level (Figure 2). They aimed to assess public perception of MPs from multiple perspectives: the general degree of awareness, the social, economic, and ecological dimensions of the perceived risk, and the influence of the media on the formation of public opinion. The quantitative research was conducted through structured response questions, which allowed the assessment of the level of awareness of perceived risks, while the open-ended questions brought a qualitative element, providing a detailed understanding of the respondents' opinions and perceptions. Each of these methodologies is detailed in the corresponding sections of the thesis, providing a full description of the methods, tools, and techniques used to reflect the specificity of each research objective and to support the validity of the results obtained.

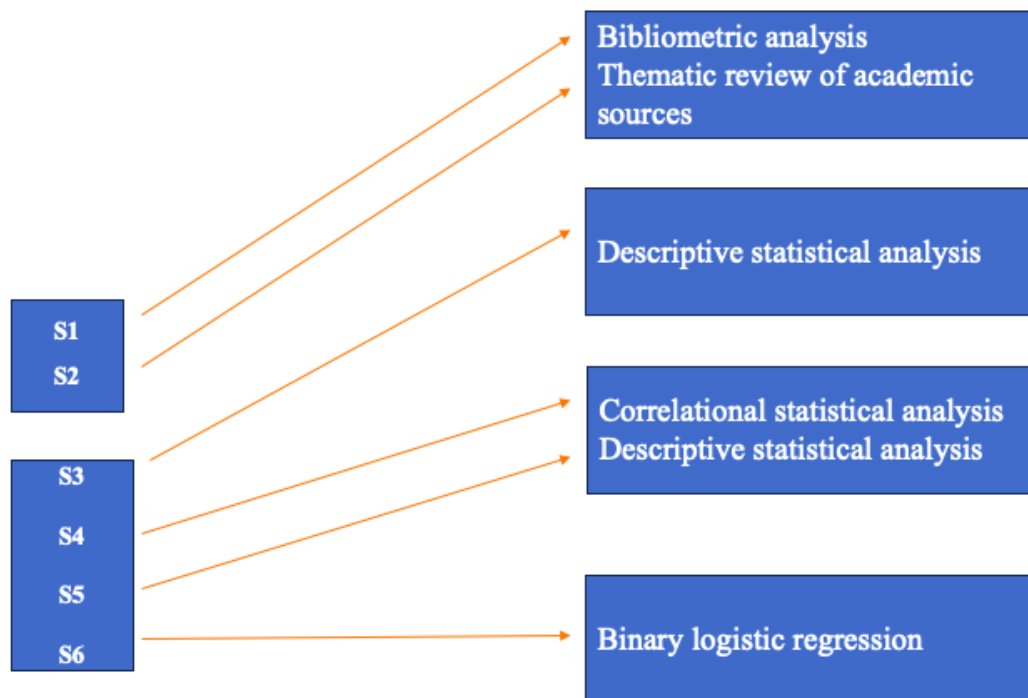


Figure 2. Methodological framework of the research

Note: S - Case study

2. Results

2.1. Bibliometric Analysis

The two case studies presented in this chapter, to which the author of the thesis contributed as a co-author, offer an integrated perspective on the issue of MPs pollution in Romania, analyzing both the scientific dimension and the political and institutional implications. The bibliometric analysis (Figure 3) carried out in the first study, on articles indexed in Web of Science and Scopus, allowed the identification of thematic clusters relevant to the field of research on plastic pollution and MPs in Romania. The main clusters outlined include terms associated with: Romania, plastics, recycling, pollution, circular economy, and waste management. Co-occurrence maps reveal a concentration of scientific interest around 2020, suggesting a recent emergence of this topic in a national context. Comparatively, the Scopus database offers a broader and more integrative coverage of the analyzed topic. Regarding marine pollution, the results indicate a significant contamination of the Romanian coastal area and the Black Sea region, mainly attributable to tourism and fishing activities. The proportion of artificial polymers in the total waste identified on beaches exceeds, in most locations, the 80% threshold, with maximum values of over 90%. In terrestrial environments, data on the presence of MPs are still limited, but international literature indicates a high potential for soil contamination, especially in the vicinity of agricultural, urban, and industrial areas. These findings highlight the urgent need to deepen national research on the impact of plastic and MPs on the environment (Mihai et al., 2024).

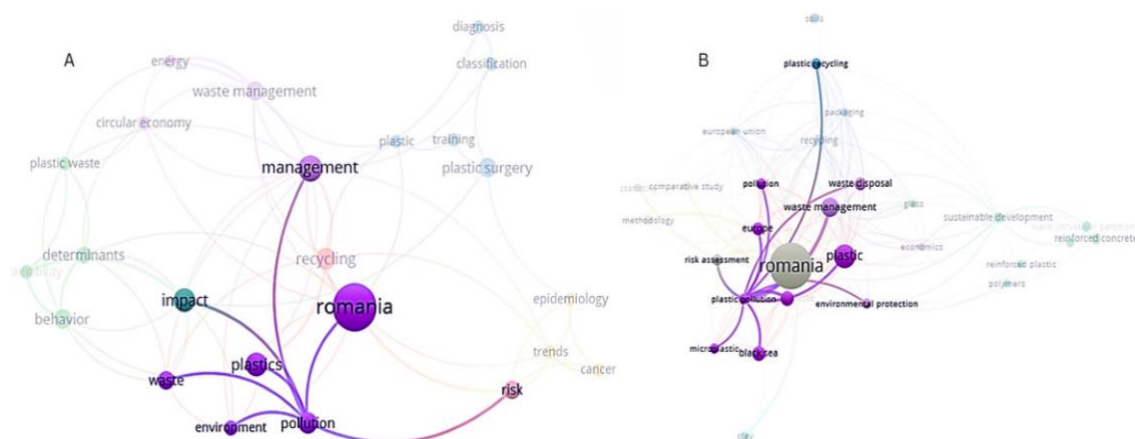


Figure 3. (A) Network visualization with focus on pollution-WoS. (B) Network visualization with focus on plastic pollution-Scopus (Mihai et al., 2024)

Note: Meaning of colors: different clusters formed. Figure created using VOSviewer

2.2. Strategies for Reducing Microplastic Pollution

In case study number 2, the thesis provides an interdisciplinary thematic analysis of MPs pollution in freshwater and soil ecosystems through the lens of environmental regulations and sustainable management strategies. Given the emerging pollutant status of MPs and the difficulties associated with their monitoring and regulation, the study highlights the multiple sources of contamination, from wastewater and agriculturally applied sludge to the degradation of plastic waste. From an institutional perspective, the challenges of implementing international, European, and national policies are analyzed, highlighting regulatory gaps, fragmentation of responsibilities, and the lack of technical standards. The paper proposes concrete measures to improve governance, including innovative technologies, sectoral integration, public education, and the promotion of the circular economy (Mihai et al., 2025). Thus, the study contributes to strengthening the analytical and normative framework necessary for the prevention and efficient management of MPs pollution in Romania.

2.3. Analysis of Perceptions Regarding Microplastic Particles Based on Applied Surveys

2.3.1. Socio-demographic Characteristics of the Sample

This section presents the socio-demographic characteristics of the pooled sample, resulting from four successive waves of research, each using the same instrument, a standardized questionnaire. Each was oriented towards a specific set of questions extracted from the general questionnaire, which allowed for an in-depth exploration of the different dimensions of public perception and behavior towards MPs pollution. This approach provided methodological coherence and comparability between data waves.

The main purpose of this subsection is to synthesize the socio-demographic profile of the participants, thus contributing to contextualizing the interpretation of the results. The data are ordered according to the size of the samples, from the smallest to the largest, which provides an evolutionary perspective on the expansion of the database and facilitates a coherent comparative analysis between the characteristics of the respondents. In the results area, these waves follow the red thread of the thesis, moving from the general perception of MPs, to the economic dimensions, the perception of risk, and, finally, the influence of the media.

The questionnaire was structured in four main sections, designed to capture relevant socio-demographic and attitudinal variables. It included 17 questions, both closed and open, intended to capture quantitative and qualitative dimensions of the perception of MPs and soil

pollution (Pop et al., 2023). At the beginning of the instrument, a brief explanation of the concept of MPs was introduced to ensure a uniform level of understanding among respondents and to reduce misinterpretations. The section dedicated to environmental behavior and awareness level targeted pro-environmental habits, the degree of information on the risks associated with soil pollution, as well as exposure to information about MPs in the media (Pop et al., 2023). The socio-demographic profile included variables such as gender, age, level of education, monthly income, occupation, and area of residence (Table 1). These data are essential for analyzing the correlations between the personal characteristics of the respondents and their attitudes towards the MPs issue. The responses were evaluated on a Likert scale from 1 to 7, where 1 indicates a minimum level of agreement or knowledge, and 7 a maximum level. Data collection was carried out by the provisions of the General Data Protection Regulation (GDPR).

The first wave of research, conducted between May and July 2022, included a convenience sample of 417 respondents from 24 counties of Romania, including the Municipality of Bucharest (Figure 4).

Table 1. Summary profile of respondents (Pop et al., 2023)

Variables	Categories
1) Gender (% of sample)	Female: 67,9%; Male: 32,1%; Unspecified: 0%
2) Education (level completed)	8 grades: 4,1%; 12 grades: 29,7%; university: 66,2%
3) Living environment (% of sample)	Urban area: 81,3%; Rural area: 18,7%
4) Age (years; mean)	38.5 ani
5) Monthly income/family	3000 lei (600 Euro):20.6%; 3001-6000lei (601-1200 Euro): 35.3%; 6001-9000 lei (1201-1800 Euro): 9001-12000 lei (1801-2400 Euro): 19.4%

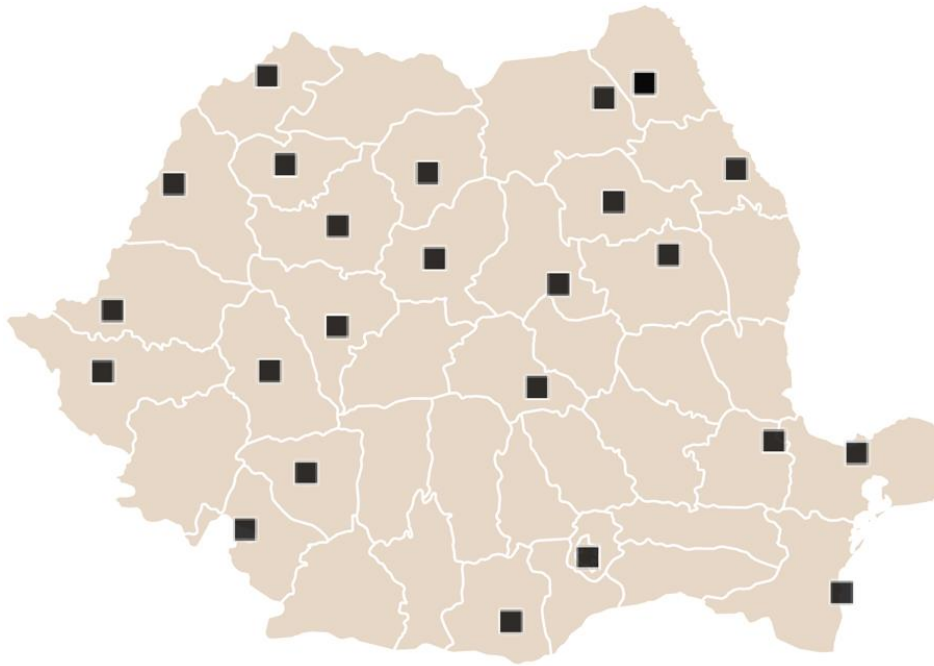


Figure 4. Location of interviewed people on the map of Romania (Pop et al., 2023)

A second wave of data collection, conducted in the fall of 2024, aimed to expand the response base by addressing the questionnaire to both local and regional authorities and the general public. The sample obtained included almost 460 respondents from a significant number of counties, with an uneven geographical distribution, reflecting areas with a high interest in the topic addressed. Most of the responses came from urban areas, which may suggest a higher sensitivity of the urban population to the issue of soil pollution with MPs. However, the role of rural areas remains essential, especially in the context of the impact on agriculture and the quality of fertile soils, which can be affected by sources of contamination such as degradable packaging or residues from agro-industrial activities. The third wave, conducted in the same period of 2024, targeted the perception of the effects of MPs on health, the environment, and the safety of the food chain. The sample consisted of almost 460 respondents, with a similar geographical distribution to the previous one. In terms of education, over 65% had university degrees. The latest research significantly expanded the sample size, reaching 569 respondents. The questionnaire was distributed online, through various digital channels (Messenger, WhatsApp, SMS, e-mail). Although effective, this method involves limitations related to representativeness, as 82% of the respondents came from urban areas. The gender distribution was > 60% among women (Pop et al., 2025), and in terms of monthly family income, the respondents were divided into four categories, covering a relatively balanced economic spectrum (Pop et al., 2025).

2.3.2. Synthesizing Public Perceptions on Microplastic Pollution: Comparative Results from Applied Research

The case studies presented in this paper provide an in-depth assessment of the environmental, health, and economic impacts of MPs pollution, as perceived by the Romanian public. This research combines both quantitative and qualitative approaches to analyze not only the level of public awareness but also the demographic and media factors that influence these perceptions. The case studies also explore the complex aspects of the perceived risks and social impact of MPs pollution, providing a deeper understanding of the dynamics of this phenomenon in a Romanian context.

The study on general perception explores the level of public awareness in Romania regarding the presence and impact of MPs on health and the environment. Preliminary results indicate a moderate familiarity of respondents with the topic, more pronounced regarding the effects on soil than regarding accumulation in the food chain. Although most have heard of MPs, detailed knowledge remains limited, highlighting the need for more effective educational campaigns. Compared to other countries, such as Germany or Bangladesh, the data suggest that Romania is at an intermediate level of awareness, which offers important opportunities for information and awareness-raising interventions.

The results presented in this section are taken, with permission from Springer Nature, from the article published by Pop, V., Ozunu, A. and Irankunda, E. (2025), entitled “Assessment of Economic, Social, and Perceptual Impacts of Soil Pollution by Microplastic Particles in Romania”, in the journal *Water, Air, & Soil Pollution*. The study analyzed three essential dimensions of the perception of soil pollution by Microplastic Particles: the economic burden associated with mitigation measures (Q1.2), the perceived social problems (Q2.2), and the likelihood of being affected by these problems (Q3.2) (Figure 5). Descriptive statistical analysis revealed high mean values for all three questions (Q1.2 - 5.17; Q2.2 - 5.01; Q3.2 - 4.69), suggesting a high level of concern (Pop et al., 2025). The strong correlations between the dimensions (Q1.2-Q2.2: $r = 0.933$, $p = 0.002$; Q1.2-Q3.2: $r = 0.861$, $p = 0.013$; Q2.2-Q3.2: $r = 0.971$, $p < 0.001$) highlight a clear interdependence between economic, social aspects and risk perception. The novelty of the research lies in the application of this analysis in the Romanian context, where soil pollution with MPs has not previously been scientifically addressed, highlighting the need for integrated policies and increased public awareness (Pop et al., 2025).

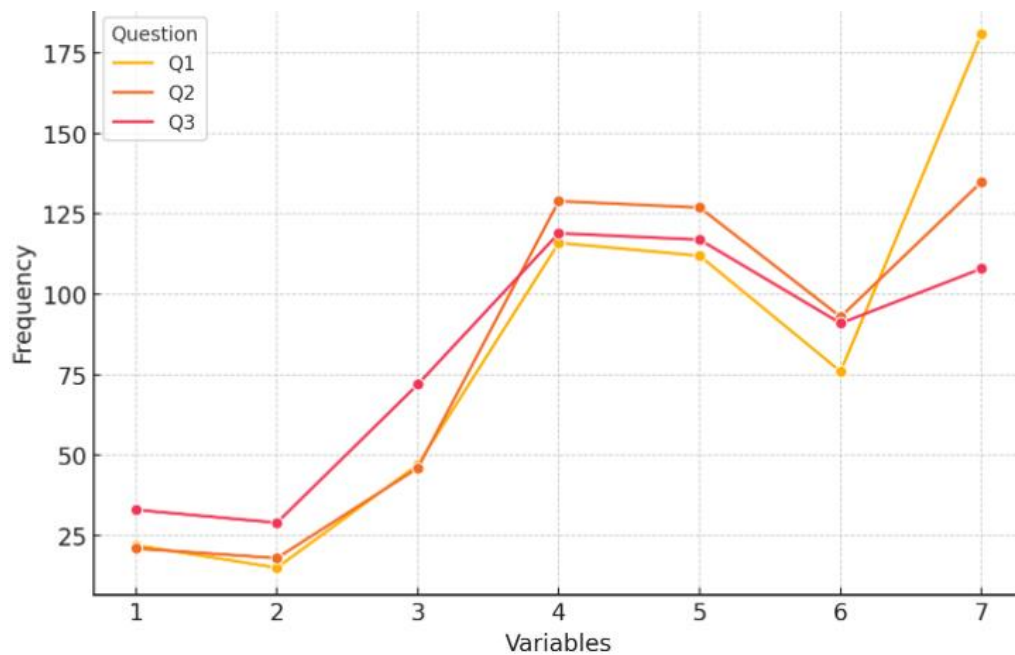


Figure 5. Distribution of trends for each variable for survey questions (Q) on soil pollution caused by MPs in Romania (Pop et al., 2025). Reproduced with permission from Springer Nature

A third study looked at public perceptions of the social and economic risks posed by MPs soil pollution. Preliminary results indicate a high level of concern among respondents about the impact of this pollution, particularly in terms of the consequences for local communities. The data suggest a correlation between perceptions of social and economic risks and personal concerns about exposure to these effects.

Public awareness and media influences: The results suggest that while general awareness of MPs pollution is still at a moderate level, there is growing concern about the risks associated with it, particularly in terms of health and the environment.

Table 2. Dependent variable: Awareness of MPs (Pop et al., 2023)

Dependent Variable: Awareness of MPs						
Independent Variables	B	S.E.	Wald	df	Sig.	Exp(B)
1) MPs from the sea threatened fish stocks	.297	.091	10.649	1	.001	1.346
2) Age	.040	.008	25.750	1	.000	.814

Note: B is the regression coefficient; S.E. is the standard error; Wald is the Wald statistic; df is the degree of freedom; p is the significance; Exp(B) is the odds ratio.

Table 3. Dependent Variable: Perceived Health Risk of MPs (Pop et al., 2023)

Dependent Variable: Perceived Health Risk of MPs						
Independent Variables	B	S.E.	Wald	df	Sig.	Exp(B)
1) Leakage of harmful chemicals from MPs affects soil	.426	.174	5.991	1	.014	1.531

Note: B is the regression coefficient; S.E. is a standard error; Wald is the Wald Statistic; df is the degree of freedom; p is the significance; Exp(B) is the odds ratio

Table 4. Dependent Variable: Perceived Environmental Risks of MPs (Pop et al., 2023)

Dependent Variable: Perceived Environmental Risks of MPs						
Independent Variables	B	S.E.	Wald	df	Sig.	Exp(B)
1) Harmful Chemical Spills from MPs Affect Soil	.544	.192	8.030	1	.005	1.723
2) MPs Causes Respiratory Diseases	.450	.194	5.378	1	.020	1.568

Legend: B is the regression coefficient; S.E. is the standard error; Wald is the Wald Statistic; df is the degree of freedom; p is the significance; Exp(B) is the odds ratio.

Factors such as age, education, and exposure to media narratives are strongly correlated with perceptions of the risks of MPs pollution (Tables 2, 3, and 4). For example, the media plays a key role in shaping public opinion through reports of the negative impacts of MPs on marine biodiversity and human health. These narratives influence public opinion, reinforcing the perception that MPs pose a significant threat, even in the absence of clear scientific evidence or adequate information.

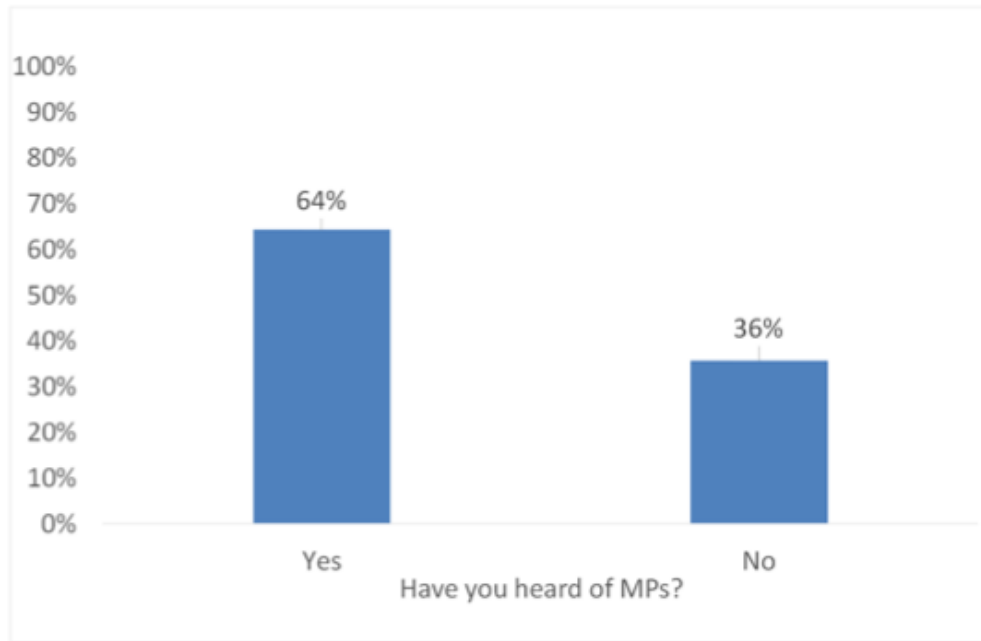


Figure 6. Awareness of MPs (Pop et al., 2023)

Overall, the case studies in this paper have demonstrated that the phenomenon of MPs pollution represents an ecological and social problem of utmost importance, which requires a rapid and coordinated response at national and global levels. Public awareness (Figure 6), the development of scientific research, and the implementation of effective environmental policies are essential to minimize the impact of this phenomenon and protect public health and the environment for future generations. The research results suggest the need for clear and urgent policy interventions, supported by quality environmental education and detailed scientific research, to substantiate decisions and measures to combat MPs pollution.

3. Final Analysis and Impact of the Research

3.1. Synthesis of Research Results on Microplastic Particles

The results obtained in the studies presented in this paper provide a detailed picture of the complexity of the phenomenon of MPs pollution in Romania, highlighting both the theoretical dimension of the problem and the perceptions and empirical realities related to this emerging topic. The bibliometric analysis carried out in case studies S1 and S2 revealed a relatively recent concentration of research in the field of plastic pollution, with an increase in interest in this topic starting in 2020. Despite a growing interest, research in Romania is still fragmented, and knowledge gaps persist, especially regarding MPs pollution levels, the impact

on ecosystems, and possible solutions to combat this problem. Thus, the study suggests that there is an urgent need to strengthen research in the field by adjusting assessments to regional specificities and by exploring various sources of pollution, including those related to landfills, waste imports, and agricultural activities.

On the other hand, public perception studies highlight a low level of awareness of the population regarding the impact of MPs on the environment and health, especially regarding their accumulation in the food chain and long-term effects on terrestrial and aquatic ecosystems. According to the results obtained through opinion polls, knowledge regarding MPs is limited, and concerns regarding environmental and health risks are moderate, which highlights the need for educational campaigns and public information strategies aimed at supporting the transition to sustainable behaviors. The results also showed a strong correlation between awareness and exposure to media narratives about MPs, which suggests that the media plays a significant role in shaping perceptions of their associated risks.

In conclusion, the synthesis of the results obtained in this paper highlights the complexity of the MPs pollution problem in Romania, from the perspective of scientific research, public perception, and environmental impact. These results suggest that, despite recent progress, an integrated and systematic approach to research and strategies for the prevention of MPs pollution is needed, involving collaboration between researchers, authorities, and the general public. The thesis provides a solid basis for the development of effective public policies and concrete measures to reduce MPs pollution, contributing to a better understanding of their impact on health and the environment, in the economic and social context of Romania.

3.2. Methodological Limitations

While the synthesis of the results has highlighted key aspects of MPs pollution in Romania, it is also important to mention the methodological limitations of the research, which may influence their interpretation and applicability. An important limitation of this study is the size and representativeness of the sample, which, although adequate to explore the perceptions of the general public, may not fully capture regional or socio-demographic variations related to the impact and likelihood of MPs pollution. Overall, the results highlight the importance of recognizing MPs pollution as a multidimensional problem, requiring integrated solutions that address the impact on health, the environment, and the economy, thus providing a solid basis for the conclusions and recommendations formulated in the following section.

Several limitations of the study are presented below. A representative sample at the country level would have helped to extrapolate the results to the entire population. The sample was not gender balanced (Pop et al., 2023) as women represented >60% of the sample and are known to experience higher levels of media exposure, especially on social media (Su et al., 2020). Furthermore, the risk of online surveys is that respondents may not be able to be contacted and thus receive further explanations. They may complete the questionnaire by quickly clicking on each question without reading carefully, which could influence responses and reduce the validity of the data (Pop et al., 2023). Another limiting factor is the self-selective nature of respondents who choose to participate in online surveys, which may affect the representativeness of the sample through biased selection. The study also did not explore in detail contextual factors that may influence participants' perceptions, such as education (Pop et al., 2023). Another limitation is the lack of rigorous control of external variables, such as access to accurate information about MPs pollution, which may affect the level of awareness of respondents. In future research, a larger sample, balanced from a socio-demographic point of view and with stricter control over the context of participation, could provide better generalization of the results.

3.3. Personal Contributions

A key contribution of this work is the first bibliometric analysis in Romania dedicated to studies on plastic pollution and MPs. The analysis aimed at mapping the relevant scientific production, with a focus on the evolution of the research volume, dominant themes, international collaborations, and the dynamics of academic interest in this subject. The results provide a coherent and documented picture of the development of the field, highlighting the major research directions at a global level and, in particular, their underrepresentation in the Romanian context. This contribution has a double value: on the one hand, it substantiates the theoretical basis of the work and, on the other hand, it emphasizes the need for increased scientific involvement in Romania, providing a useful reference framework for future research in the field.

In continuation of this theoretical basis, the work makes significant contributions in the field of applied research, approaching the problem of MPs pollution from a multidimensional perspective. The research provides an in-depth understanding of the population's perceptions and behaviors towards this global phenomenon, while also contributing to the development of a clear framework for assessing the impact of MPs on health, the environment, and the economy.

Innovative study on perceptions and behaviors related to MPs pollution: One of the main contributions of this work consists of the development and application of a detailed questionnaire, designed to assess the public's perception of MPs pollution and the behaviors associated with this topic. The results highlight the need for educational and public policy interventions to increase awareness of the dangers of MPs pollution.

Risk assessment and economic, health, and ecological impacts: The work fills an important gap in the specialized literature, by providing a detailed assessment of the perceived risks and real impacts of MPs on the economy, health, and the environment, with a special focus on the national context of Romania. This research brings a new perspective on the level of awareness and perception of risks among the population, a topic that has been insufficiently addressed so far. In addition, the lack of in-depth economic studies on the costs and effects of MPs pollution in Romania makes the work a valuable starting point for future interdisciplinary research.

Implications for public policy and environmental education: Another significant contribution of the work consists of highlighting the direct applicability of the results in the field of public policy and environmental education. Based on the results obtained, more effective awareness campaigns and intervention strategies can be developed, focused on informing and educating the population about the effects of MPs pollution. The study also proposes integrated solutions that simultaneously address the ecological, economic, and educational dimensions of the problem.

In conclusion, through these contributions, the paper brings significant added value to the field of research on MPs, offering a new perspective on public perception, evaluating the multiple impacts of this type of pollution, and providing concrete solutions, both at a theoretical and applied level. Next, the answers to the research questions stated in the first part of the thesis will be addressed to analyze and synthesize the results obtained during the study.

3.4. Answer to the Research Questions

Regarding the state of research on MPs in Romania, the analysis of the specialized literature revealed an incipient level of research, with important gaps such as the absence of a national database on the distribution and typology of MPs, the lack of in-depth studies on the impact on human health and the economy, as well as the deficit of standardized monitoring methodologies. International studies provide models of good practices that can be adapted to the national context to support the development of environmental policies and the circular

economy. Regarding Romania's positioning in the European context and the population's perception of MPs pollution, the results indicate a low level of awareness, especially regarding the long-term risks associated with the accumulation of MPs. These findings highlight the need to implement educational and information campaigns aimed at raising awareness and promoting sustainable behaviors.

Regarding the influence of the media on the perception of risks related to MPs, the study highlighted a significant impact of media narratives on the level of information and concern of the public, especially regarding environmental and health contamination. Also, the age of the respondents proved to be an important factor in the level of awareness, emphasizing the need for communication strategies adapted to the target groups. These responses provide a solid basis for the development of future directions of research and intervention in the field of MPs, intending to contribute to the protection of the environment and public health.

3.5. Future Perspectives

The present work has made significant contributions in the field of public perception of MPs pollution, but there are many directions in which research can be expanded. In this regard, future studies could address the following aspects:

Sample expansion and national/international representativeness: (i) The current research provided a clear picture of public perceptions, but a larger and better-balanced sample from a geographical and socio-demographic point of view could strengthen the results. (ii) Comparative studies between different regions or between Romania and other countries could provide a broader understanding of how cultural and economic factors influence the perception of MPs associated risks.

Investigating behavioral impact: (i) An important aspect that could be analyzed in the future is the extent to which the level of awareness influences actual behavioral changes. (ii) Future studies could include longitudinal experiments to observe whether and how attitudes and behaviors towards MPs change over time, following awareness campaigns.

Economic evaluation of MPs pollution: (i) Future research could include more precise estimates of the economic costs of MPs, both in terms of public health and the impact on affected industries (agriculture, fisheries, tourism). (ii) More detailed economic models could help formulate more effective policies to reduce the impact of MPs on the economy.

Expanding interdisciplinary collaborations and future directions for applied research: (i) Although the current study focuses on perception and behavior, future research could

integrate data from environmental and health sciences to correlate public perception with objective data on pollution and health risks. (ii) Collaborations with experts from the fields of chemistry, biology, and medicine could contribute to a deeper understanding of the effects of MPs on living organisms and ecosystems. By taking a more active role in the conduct of these studies, as the lead author, it is intended to strengthen an applied research direction, with an emphasis on the integration of environmental science, public perception, and advanced analysis of contaminants. This transdisciplinary approach can significantly contribute to the development of effective national strategies for reducing MPs pollution, in line with the principles of the circular economy and long-term sustainability.

Public policy proposals and measures to reduce MPs pollution: (i) Based on the results obtained, educational and intervention strategies to reduce MPs pollution can be developed, including recommendations for government policies. (ii) Future research could analyze the effectiveness of measures such as banning certain types of plastic, promoting biodegradable alternatives, or introducing more efficient collection systems. In conclusion, this work provides a solid basis for future studies on MPs and public perception, opening new directions of interdisciplinary research, with both scientific and practical implications for environmental protection and public health.

3.6. Dissemination of Results

Dissemination activities are materialized through: articles published in international journals (ISI). There are 9 ISI in total, of which 5 have the PhD student as the main author. In addition to dissemination in ISI articles, scientific dissemination was also done in 5 BDI articles (international databases), as well as in international and national conferences.

Publications in ISI scientific journals

- **Pop V., Ozunu, A., Petrescu, D. C., Stan, A.-D., & Petrescu-Mag, R. M. (2023).** The influence of media narratives on microplastics risk perception. *Peerj*, DOI10.7717/peerj.16338, IF 2,7;
- **Pop V., A. Ozunu, E. Irankunda (2025).** Assessment of Economic, Social, and Perceptual Impacts of Soil Pollution by Microplastic Particles in Romania. *Water, Air & Soil Pollution, Springer*, <https://doi.org/10.1007/s11270-025-08038-3>, IF 3,8;

- **Pop, V.**, A. Ozunu, E. Irankunda, (2025), Analysis of Public Awareness and Perception of Microplastic Particles in Roumania, *Revue Roumaine de Chimie*, DOI: 10.33224/rrch.2025.70.5-6.13, IF 0,6;
- **Pop V.**, Z. Torok, M.D. Gavriletea, E. Irankunda, A. Ozunu, (2025), Perceived Risk of Human Exposure to Microplastics: A Probability and Impact-Based Assessment, *Journal of Environmental Engineering and Science*, (Submitted- under peer-review), IF 1;
- **Pop V.**, A. Ozunu, E. Irankunda, Are Microplastic Particles in Our Everyday Life? Hidden Sources and Accessible Solutions- Systematic Review, (2025), *Revue Roumaine de Chimie*, DOI: 10.33224/rrch.2025.70.7-8.01, IF 0,6;
- A. Ozunu, E. Irankunda, **V. Pop**, Z. Cui, A. Craciun (2024). The Critical Analysis of Air Pollution and Soil Pollution with Microplastics, and Heavy Metal in Rwanda, Romania, and China. *Revue Roumaine de Chimie* -Corresponding author DOI: 10.33224/rrch.2024.69.9.04, IF 0,6;
- Mihai, F. C., Ulman, S. R., & **Pop, V.** (2024). Macro and microplastic pollution in Romania: Addressing knowledge gaps and potential solutions under the circular economy framework. *PeerJ*, 12, e17546. <https://doi.org/10.7717/peerj.17546> IF 2,7;
- Nesterovschi I., Marica I., Condor D., Couti A., **Pop, V.**, E. Levei., Pinzaru S. (2025). Have you ever seen microplastic? A collaborative high school-academia approach for identification, quantification, and raising awareness on microplastics in river-crossing urban areas. *The Journal of Chemical Education*, <https://doi.org/10.1021/acs.jchemed.4c01484>, IF 2,5;

Book chapters

- Mihai, FC, **Pop V.**, Ulman S. R., Ozunu A., (2025). Policy Implementation and Management of Microplastics in Freshwater and Soil, in: Handbook of Microplastic Pollution in the Environment. CRC Press, Boca Raton, pp. 367-397.
<http://dx.doi.org/10.1201/9781003487593-14>

BDI

- **V. Pop**, A. Ozunu, (2022) The involvement and attitude of Romanians in pro-environmental activities related to the risk of microplastic particles- *Scientific and Technical Bulletin, Series: Chemistry, Series: Chemistry, Food Science and Engineering*
- **V. Pop**, M. Petrescu - Mag, C. Petrescu, A. Ozunu, (2023) The risk of microplastic particles seen through the future actions of Romanians, *Bulletin of Romanian Chemical Engineering Society*
http://sicr.ro/wp-content/uploads/2023/12/BRChES_Vol_10_nr_1_2023.pdf
- **V. Pop**, A. Ozunu (2024). The degree of awareness of the risk of microplastic particles/people's perception in taking preventive measures for this type of risk. *Journal of Engineering Sciences and Innovation (JESI)* https://jesi.astr.ro/wp-content/uploads/2024/06/8_Valeria-Pop.pdf
- **V. Pop**, A. Ozunu (2024). Evaluation of research interests for microplastics in Romania, *Bulletin of Romanian Chemical Engineering Society*
<https://www.proquest.com/docview/3225016717/fulltext/13DFF4CDD50E485CPQ/4?accountid=8013&sourcetype=Scholarly%20Journals>
- A.A. Budihoi, **V. Pop**, A. Ozunu, M. Popa, The effects of microplastic and nano plastic particles on the environment and the human body, *The Journal of School and University Medicine*, 2024, <https://www.revista-medicina-scolara.ro/>
- **V. Pop** (2022). Living with plastic for over 100 years - Consequences for human health - Climate info - The science behind climate change - Press article

International and national conferences

- IDRIM 2022 (Romania-Japonia, (2022)- Critical steps for research and practice in disaster risk management in the age of climate change and Covid-19 pandemics; Lucrare- *The role of the media in shaping people's risk perception of microplastic*;

- Insight on Academic Writing, (2022), University of Auvergne/ Babes Bolyai University- *Educație de calitate*;
- International Chemical Engineering and Material Symposium; SICHEM (2022). Bucharest, Romania; Lucrare: *The risk of microplastic particles seen through the future actions of Roumanian*;
- Phd. Students' Day, Arad, Romania, (2022); Lucrare: *The involvement and attitude of Romania in pro-environmental activities related to the risk of microplastic particles*;
- ENVIRONMENT & PROGRESS Symposium (2023), Faculty of Environmental Science and Engineering, Babeș Bolyai University, Cluj-Napoca, with the theme Sustainable development: approaches and solutions for resilient communities; Paper: Awareness of the risk of environmental pollution/Romanians' attitude towards this global danger/Mps;
- PhD Students' Days, (2023), Faculty of Food Engineering, Tourism, and Environmental Protection, the third edition, Arad, Romania; Lucrare: *The involvement and attitude of Romanias in pro-environmental activities related to the risk of microplastic particles*;
- International Conference, (2023), Satu Mare/ The impact of micro and macro plastic on the Someș River and implicitly on population health. Performance in assessing the degree of pollution of the Someș River with microplastics. Paper: Evaluation of perception, attitude, and behavior regarding pollution with microplastic particles;
- ASTR, Technical Sciences Academy of Romania, Brasov (2023). Lucrare: Gradul de constientizare al riscului particulelor de microplastic /perceptie/masuri preventive;
- SICHEM, International Chemical Engineering and Material Symposium (2024). Lucrare: *Evaluation of research interests for microplastics in Romania*;

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Appendices



Figure 1 (A). Certificate of participation in the Academic Writing Training session

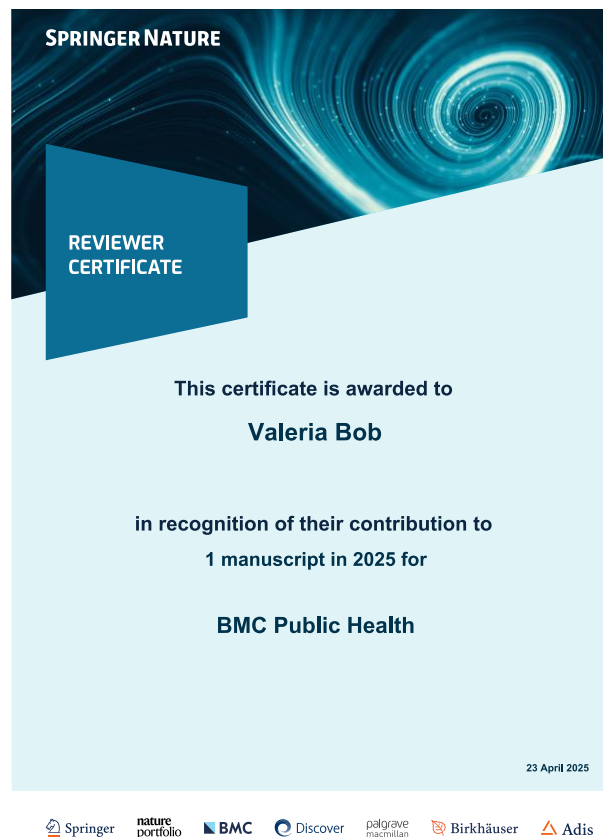


Figure 2 (A). Springer Nature certificate

