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Contents

Ivan Boev SECONDARY MINERALS IN THE ALLCHAR ORE DEPOSIT, N. MACEDONIA WITH PARTICULAR REFERENCE TO SEM VIEW.....	4
Afrodita Zendelska, Sonja Lepitkova, Dejan Mirakovski, Nikolinka Doneva, Marija Hadzi-Nikolova, Gorgi Dimov, Dusica Trpcevska Angelkovic GHG EMISSIONS FROM MUNICIPAL SOLID WASTE IN NORTH MACEDONIA.....	15
Ivica Andonov, Ivica Andov, Sonja Lepitkova, Afrodita Zendelska, Gorgi Dimov PHYTOREMEDIATION OF CONTAMINATED SOILS IN THE VICINITY OF PROBISHTIP, REPUBLIC OF NORTH MACEDONIA.....	22
Stojance Mijalkovski, Vasko Stefanov, Dejan Mirakovski SELECTION OF THE LOCATION OF THE MAIN WAREHOUSE USING THE EDAS METHOD.....	32
Irena Taseva, Marija Hadzi-Nikolova, Dejan Mirakovski, Nikolinka Doneva, Afrodita Zendelska ERGONOMIC WORKSTATION DESIGN IN AUTOMOTIVE CAR SEATS PRODUCTION.....	39

GHG EMISSIONS FROM MUNICIPAL SOLID WASTE IN NORTH MACEDONIA

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Abstract

Emissions of greenhouse gases (GHG) from municipal solid waste (MSW) in North Macedonia are a serious issue for the environment and major efforts are needed to mitigate climate change. In order to determine the current situation with the GHG emissions in North Macedonia, several calculations were made and results and proposals for reduction of GHG emissions, related with waste, are presented in this paper.

Municipal solid waste (MSW) management, primarily through landfilling, is a major contributor to GHG emissions in North Macedonia. The anaerobic decomposition of organic waste in landfills generates methane (CH₄), a strong greenhouse gas with a high global warming potential, even 25 times more than carbon dioxide (CO₂). Furthermore, open waste burning and inadequate waste management techniques lead to the release of CO₂, nitrous oxide (N₂O), and other pollutants.

Despite efforts to mitigate GHG emissions from waste, challenges persist due to inadequate waste management infrastructure, limited waste reduction and recycling initiatives, and failure to implement regulatory frameworks. These challenges exacerbate the environmental impacts of waste management and hinder progress towards sustainable development goals.

To tackle GHG emissions from waste in North Macedonia, a comprehensive approach is required that includes legislative interventions, technological advances, and public engagement techniques. Improving waste management infrastructure, promoting waste reduction and recycling, investing in waste-derived renewable energy, and enhancing regulatory enforcement are among the key recommendations.

Key words: *Greenhouse gas emissions, methane, carbon dioxide, planning region, MSW.*

INTRODUCTION

Increasing concern about climate change is prompting organizations to mitigate their greenhouse gas emissions. Waste management activities also contribute to greenhouse gas emissions. In the waste management sector, there has been an increasing diversion of waste sent to landfill, with much emphasis on recycling and reuse to prevent emissions [1].

Efforts to address GHG emissions on global level have been ongoing for several decades, but significant attention to the issue began to accelerate notably in 1970s-1980s when the scientific community begins to raise concerns about the potential impact of GHG emissions on the Earth's climate. In 2000s we witnessed an increasing awareness of climate change issues globally, and in 2020s efforts to combat climate change intensified further, with increased focus on transitioning to low-carbon and renewable energy sources, enhancing energy efficiency, promoting sustainable land use and agriculture, and waste management and fostering international cooperation. In 2017 most emissions come from combusting fuels (77%), followed by agriculture (10%), and industrial processes (8%) and waste is the fourth largest source sector of emissions, accounting for 3% of total greenhouse gas emissions [2]. Nowadays, the waste sector is responsible for 20% of global methane emissions and 3.3% of global greenhouse gas emissions [3].

Between 1995 and 2017, greenhouse gas emissions from waste in the EU have fallen by 42%, according to estimates by the European Environmental Agency. The emissions from waste depend on how the waste is treated. The total amount of municipal waste treated increased by 13% between 1995 and 2017, while the amount of waste that was landfilled fell by 60% over the same period [2].

Reducing GHG emissions from waste in Europe is discussed by many authors in the last decades. In 2013 Connett emphasized in "The Zero Waste Solution" the importance of reducing waste generation and maximizing recycling efforts. Encouraging waste reduction at the source and promoting recycling can significantly reduce GHG emissions associated with waste management [4]. Themelis provides insights into the technical aspects and potential benefits of waste-to-energy solutions. Implementing advanced waste-to-energy technologies can help capture energy from waste while minimizing GHG emissions [5]. Koerner and Yoshida in their studies emphasize how utilizing biological treatment methods such as composting and anaerobic digestion can help divert organic waste from landfills and reduce methane emissions [6, 7]. Also, the importance of implementing effective policies and regulations is crucial for driving systemic changes in waste management practices [8, 9] and educating the public about the environmental impacts of waste, and the importance of responsible consumption and disposal can foster behavioral changes [10] are discussed by many authors. According to Sachs, collaboration among governments, industries, academia, and civil society is essential for developing comprehensive solutions to address GHG emissions from waste [11].

The specific requirements for GHG emissions from waste management are often outlined in directives or regulations set forth by governing bodies, such as the European Union (EU). These directives typically aim to reduce the environmental impact of waste management practices, including the generation of GHG emissions. One significant directive in the EU context is the Waste Framework Directive (Directive 2008/98/EC), which sets out the legislative framework for waste management in the EU [12]. While it does not specifically target GHG emissions, it promotes waste prevention, recycling, and other measures that indirectly contribute to reducing emissions. For more specific regulations addressing GHG emissions from waste, directives such as the EU's Effort Sharing Regulation (ESR) adopted in 2018 [13] or the EU Emissions Trading System (EU ETS) [14] may be relevant. These regulations often set targets for GHG emissions reductions across various sectors, including waste management.

With substantial ramifications for both sustainable development and the mitigation of climate change, waste management is an essential component of environmental stewardship. Like a number of other countries, North Macedonia faces difficult issues when managing its municipal solid waste (MSW), and the production of greenhouse gas emissions. These emissions contribute to global warming and climate change, mostly in the form of carbon dioxide (CO₂) and methane (CH₄), which emphasizes the significance of comprehending and efficiently addressing them.

This paper aims to provide a comprehensive overview of GHG emissions from waste in North Macedonia. By examining the sources, trends, and impacts of these emissions, we can identify key challenges and opportunities for improving waste management practices and reducing environmental impacts. The obtained results from the determination of the GHG emissions and the proposals for their reduction, related with waste in the country, are presented in this paper.

CURRENT SITUATION WITH MUNICIPAL SOLID WASTE MANAGEMENT IN NORTH MACEDONIA

Waste management in North Macedonia faced several challenges, including inadequate infrastructure, limited recycling and waste reduction initiatives, and significant reliance on landfilling. However, there were also ongoing efforts to improve waste management practices and address environmental concerns.

Landfilling is still the primary method of waste disposal in North Macedonia, with limited capacity and inadequate infrastructure for waste treatment and recycling. Many landfills were operating beyond their intended capacities, leading to environmental and health concerns. The rates of recycling are relatively low compared to European standards, with limited infrastructure and public awareness initiatives for recycling and waste reduction. Illegal dumping of waste and open burning of waste are still common practices, particularly in rural areas and informal settlements. Although North Macedonia had established regulations and policies for waste management, the enforcement and implementation still are challenges.

North Macedonia is divided into eight planning regions (Fig. 1). In the period 2014 - 2020, regional plans for waste management were drawn up for all planning regions, which provided for the construction of 6 regional centers for waste management, which included: plants for selection, recycling, composting, and construction of standard landfills for disposal of the residual waste. Even though the deadlines for the implementation of these plans are approaching, the construction of these regional centers for waste management has not yet started in any planning region.

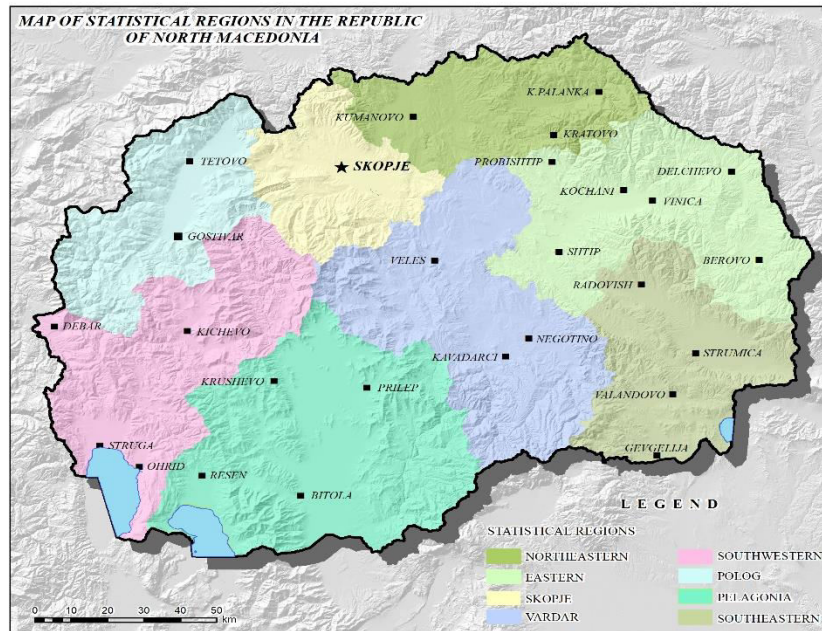


Figure 1. Map of planning regions in North Macedonia

In Fig. 2 are presented the total amounts of generated municipal waste in North Macedonia in the period 2008-2022 and the amount of generated municipal waste by regions.

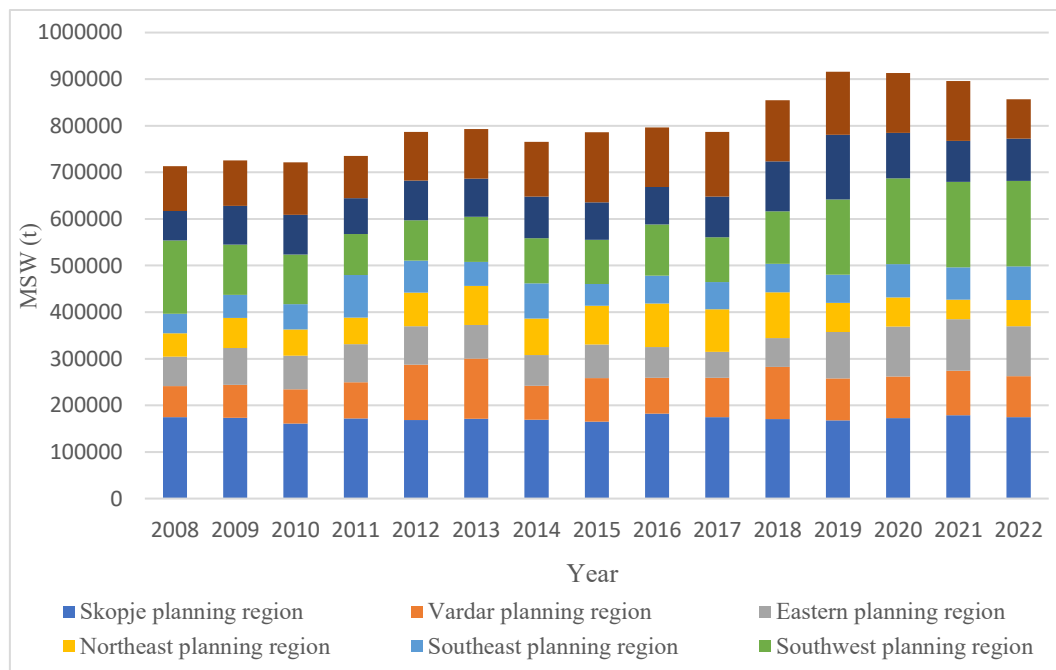


Figure 2. Amount of generated municipal waste (t) by region

Waste generation in North Macedonia was steadily increasing until 2019 due to urbanization and changes in consumption patterns. Rapid economic development also contributed to higher levels of

waste generation, particularly in urban areas. Since 2020, the trend of waste generation has changed, but although the trend is decreasing, it is still at a very high level.

CURRENT SITUATION WITH GHG EMISSIONS FROM MUNICIPAL SOLID WASTE IN NORTH MACEDONIA

GHG emissions from waste in North Macedonia are caused by a number of factors, such as: landfills, waste management practices, and lack of waste reduction and recycling. In North Macedonia, disposing of waste in landfills is the most common method. Especially, landfilled organic waste undergoes anaerobic decomposition, leading to the production of methane, a potent greenhouse gas. Also, inadequate waste segregation and open burning of waste are two examples of inefficient waste management techniques that lead to increased greenhouse gas emissions. Methane, carbon dioxide, and other pollutants are released into the atmosphere during open burning, which exacerbates climate change and air pollution. However, limited waste reduction, recycling, and composting efforts result in higher quantities of landfilled waste, where organic materials decompose anaerobically, producing methane. Increasing recycling rates and promoting composting can help reduce the amount of landfilled waste and mitigate GHG emissions.

As was mentioned before, waste generation in North Macedonia was steadily increasing until 2019, but since 2020 the trend of waste generation has changed, but although the trend is decreasing, it is still at a very high level (Fig. 2). Naturally, with the increase in the amount of generated waste, the emission of greenhouse gases also increases (Fig. 3), knowing that waste management is still at a very low level.

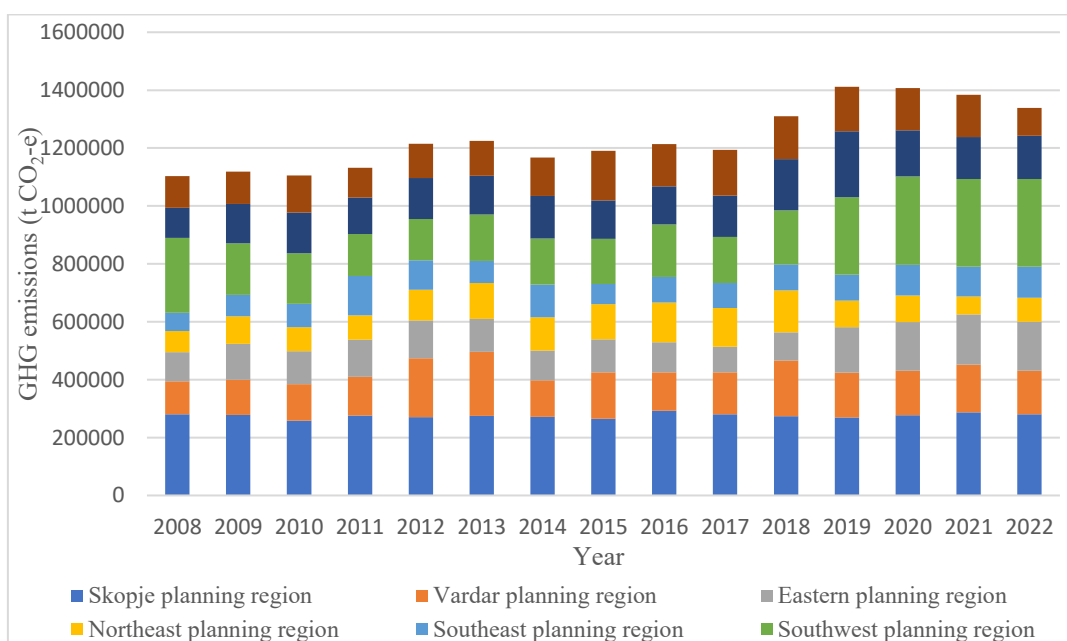


Figure 3. GHG emissions (t CO₂-e) by region

The calculations that are used to obtain GHG emissions from MSW are according to the National Greenhouse Accounts Factors (2018) [15]. The results of GHG emissions by type of solid municipal waste for each planning region in North Macedonia are presented in Figure 4. It is clearly seen that the largest GHG emissions, in each of the planning regions, come from organic waste, followed by paper and cardboard. This result was expected because the organic waste in the whole country is landfilled. There have been several attempts to promote the composting of organic waste, but, unfortunately, without much success [16-20].



Figure 4. GHG emissions (t CO₂-e) by type of MSW

Addressing GHG emissions from waste in North Macedonia requires a comprehensive approach that includes improving waste management practices.

Implementing policies to encourage waste reduction, reuse, recycling, and composting can help reducing GHG emissions and conserving resources through several practices, mainly through diverting organic waste from landfills and encouraging its composting to produce nutrient-rich soil - compost. This reduces the volume of waste sent to landfills and creates a valuable resource for agriculture and landscaping. Also, through investing in recycling facilities and collection systems to make recycling more accessible and convenient for residents and businesses, including providing recycling bins in public spaces and improving recycling programs.

Exploring alternative waste management technologies, such as waste-to-energy facilities, anaerobic digestion, landfill gas capture systems, and advanced recycling technologies to convert waste into energy or valuable resources, can help reduce GHG emissions while generating renewable energy or valuable by-products.

Raising public awareness through educating the public about the environmental impacts of waste generation and the importance of proper waste management practices can help foster behavior change and support sustainable waste management initiatives. Increasing awareness can lead to better waste segregation and disposal habits. This makes recycling and composting more efficient and reduces the burden on landfills.

Collaboration between government agencies, local communities, industry stakeholders, and international organizations is essential to develop and implement effective strategies for reducing GHG emissions from waste in North Macedonia.

CONCLUSION

Despite efforts to mitigate GHG emissions from waste management, challenges still persist. The advancement of sustainable waste management techniques is impeded by inadequate infrastructure for waste management, insufficient recycling and waste reduction programs, and non-implemented regulatory frameworks. These challenges not only contribute to GHG emissions but also impact air and water quality, soil health, and public health.

A complex strategy is needed to address North Macedonia's waste management-related GHG emissions. This entails enhancing the infrastructure for waste management, encouraging recycling and trash reduction, funding the development of alternative waste treatment technologies, and stepping up regulatory enforcement. To put successful ideas into practice and make significant progress, cooperation between government agencies, local communities, the commercial sector, and foreign partners is crucial.

Through comprehensive research and analysis, this paper seeks to contribute to the understanding of GHG emissions from waste management in North Macedonia and provide insights into potential pathways for sustainable waste management practices.

By proactively tackling these concerns, North Macedonia can reduce its impact to climate change while also promoting environmental sustainability for future generations.

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