Lana OFAK[1] – Valentina GRUBEŠIĆ ČRNELČ[2]

From Landfills to Composting: Challenges of Transforming Biodegradable Waste Management in Croatia[3]

Abstract

As the youngest member of the European Union, Croatia has made considerable efforts to align its biodegradable-waste-management practices with EU legislation. This paper examines the development of Croatia's legal and strategic framework from early national initiatives to the Waste Management Plan of 2023–2028. Despite legislative advancements, Croatia struggles with the implementation of waste management. Key issues include delays in adopting regulations and waste-management plans and insufficient infrastructure for composting and anaerobic digestion. The paper also explores successful practices, including public-awareness campaigns and financial incentives, which have contributed to improvements in separate bio-waste collection. Additionally, the paper addresses risks such as seasonal peaks in waste generation in tourist regions, public resistance to new facilities, and the accumulation of unsold compost. Recent policy measures, including the introduction of a landfill fee in 2025 and the anticipated Ordinance on HR fertilising products, are evaluated for their potential to improve outcomes. By analysing Croatia's progress and setbacks, the paper contributes to the broader discourse on sustainable waste management in EU Member States and offers practical insights for policymakers and researchers to enhance biodegradable-waste-management systems in line with circular-economy principles.

Keywords: Municipal Waste, Biodegradable Waste, Bio-Waste, Composting, Croatian Waste Management Act

1 | Ph.D., Full Professor, University of Zagreb Faculty of Law, Croatia; ORCID: https://orcid.org/0000-0001-7585-6370; e-mail: lana.ofak@pravo.unizg.hr
2 | Mag. iur., Assistant, University of Zagreb Faculty of Law, Croatia; ORCID: https://orcid.org/0009-0000-0956-6201; e-mail: valentina.grubesic.crnelc@pravo.unizg.hr
3 | *The research and preparation of this study was supported by the Central European Academy.*

Lana OFAK – Valentina GRUBEŠIĆ ČRNELČ: From Landfills to Composting: Challenges of Transforming Biodegradable Waste Management in Croatia. *Journal of Agricultural and Environmental Law* ISSN 1788-6171, 2025 Vol. XX No. 39 pp. 105–134

https://doi.org/10.21029/JAEL.2025.39.105

1. Introduction

According to the latest data, approximately 22.5% of municipal waste generated in the European Union (EU) was landfilled in 2023.[4] However, the rates of landfilling municipal waste differ significantly across EU countries.[5] Despite being considered more eco-friendly than non-biodegradable waste, biodegradable waste can still pose environmental risks if not properly managed. The primary environmental concern associated with biodegradable waste is the release of methane gas during its decomposition in landfills. Redirecting biodegradable waste to higher-level waste treatment options, such as composting and anaerobic digestion, in accordance with Directive 2008/98/EC on waste (hereinafter: Waste Framework Directive), and properly stabilising the waste before disposal, are key strategies to reduce methane emissions from waste.[6]

In 2018, the revision of the Waste Framework Directive mandated the separate collection of bio-waste by 2024. Further, Directive 1999/31/EC on the landfill of waste[7] (hereinafter: Landfill Directive) was amended with the new goal of a maximum of 10% landfilling of municipal waste by 2035. These changes lead to the anticipation of a further decrease in methane emissions from landfills.

Reducing the amount of biodegradable waste being sent to landfills and its use to create climate-neutral, circular biobased materials and chemicals is crucial in preventing the release of methane gas. This also enables the development of alternatives to fossil fuels, helping to reduce dependence on non-renewable resources.[8] For this purpose, EU Member States should strengthen the enforcement of current legal obligations, such as meeting landfill-diversion targets for biodegradable waste and properly treating biodegradable waste before disposal to mitigate its negative impact.[9]

As the youngest EU member state, Croatia has attempted to align its waste-management legislation and practices with EU law. This paper explores these practices and is organised into different sections. The paper begins with an overview of Croatian academic and legal scholarship on biodegradable waste, highlighting the limited but evolving body of literature in this field (Section 2). The paper proceeds to explore the legislative and strategic framework governing biodegradable-waste management in Croatia, including its compliance with EU goals (Section 3). Additionally, the paper will examine success stories and case studies that demonstrate effective biodegradable-waste-management practices

4 | Eurostat 2025.
5 | European Environment Agency 2025.
6 | European Commission 2020.
7 | Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste, OJ L 182, 16.7.1999.
8 | European Commission 2020.
9 | Ibid.

in Croatia, including public awareness initiatives and financial incentives. Furthermore, it will identify and discuss risks associated with biodegradable waste management and the measures taken to mitigate these risks (Section 3). By achieving these objectives, the article aims to advance the discussion on sustainable waste management in EU Member States and offer valuable insights for policymakers and researchers.

2. Overview of Croatian academic and legal scholarship on biodegradable waste

The interdisciplinary nature of biodegradable-waste management is reflected in the review of relevant literature. Despite the growing interest in this topic, there is limited academic research on the legal dimension of waste management. However, the predominant research comes from the fields of agronomy, chemistry, and biotechnology, and authors analyse the current management of biodegradable waste in Croatia and elaborate on the concept of a circular economy. Some of them emphasise composting as the most effective management method. A summary of the relevant literature is presented in the following paragraphs.

Some authors have identified sustainability achieved through the separate collection of waste as a key element of biodegradable-waste management.[10] Inadequate management leads to an increase in communal waste, greenhouse gas emissions and landfill growth.[11] According to Voća et al., to avoid potential harm to the environment and human health, waste management should be guided by hierarchical principles, beginning with waste prevention and reduction at the source and followed by the separate collection of bio-waste streams at the top of the priority order.[12] Disposal of biodegradable waste should be the last option, as it is connected with several risks and harms. Namely, disposed waste can pollute groundwater owing to the contaminated drainage. The air and atmosphere are at risk owing to odours and gases, such as methane and carbon dioxide created by chemical processes within the landfill. Waste attracts various animals as a source of food, increasing the likelihood of disease and infection transmission.[13] Another reason to use disposal as a last option is the possibility of using it for thermal and material production.

Some authors express the potential of biodegradable waste in biogas production and heat treatment. Through anaerobic digestion, waste with high organic content is converted into biogas, a form of renewable energy, which can be utilised

10 | Kantar et al. 2024, 74.
11 | List & Djedović 2024, 123.
12 | Voća et al. 2014, 28.
13 | Fuk 2020, 306.

to generate heat and electricity.[14] It is also regarded as one of the most energy-efficient and environmentally sustainable technologies.[15] According to the National Report on Communal Waste for 2024, the number of biogas plants in Croatia has increased. In 2024, 25 biogas plants took 361,167 tonnes of waste, with 51,046 tonnes being treated through anaerobic digestion. Most of this waste was biodegradable, originating from kitchens, parks, and markets.[16]

Recent studies, such as those by Hadelan et al. (2024), consider composting as the best option for managing biodegradable waste, as it is a natural and spontaneous process in which microorganisms recycle organic matter into a nutrient-rich material.[17] Compost produced is used as a fertiliser, improving the soil structure, retaining moisture, and providing essential nutrients to plants, whose roots protect the soil from erosion.[18] Composting produces mainly carbon dioxide, a far less potent greenhouse gas, unlike methane produced in landfills. Consequently, compost has a significantly lower climate impact. Besides the natural method, composting can also be done under controlled conditions in composting facilities, where the composting time is shortened from a few months to a few weeks, eliminating odours and minimising gas production. According to a National Report, there were 18 active composting facilities in Croatia last year.[19]

Significantly, biodegradable-waste management in the context of circular economy includes reuse, recycling, sharing and similar strategies, focusing on the long-term use of a resource. It aims to establish a zero-waste economy, aligning economic activities with environmental sustainability.[20] Thus, natural systems can regenerate themselves, minimising landfill creation, as waste becomes a valuable input resource for new production (biogas, biomass, compost, etc.) in the case of biodegradable waste.[21]

Despite the growing interest in this topic, a small number of studies have critically analysed the role of national, regional, and local governance in bio-waste regulations. The EU's waste policy aims to support the circular economy by maximising the recovery of high-quality materials from waste streams. Consequently, through several legal instruments, it addresses the treatment of bio-waste. However, Croatia has not yet met the EU's waste requirements.[22] One of the reasons, according to Boromisa, Golubovac and Vetma, is weak governance structures and insufficient political commitment to implementing effective waste-management

14 | Kantar et al. 2024, 74.
15 | Petravić-Tominac et al. 2020, 2.
16 | Ministry of Environmental Protection and Green Transition 2025, 48.
17 | Hadelan et al. 2024, 125.
18 | Vidović & Runko Luttenberger 2019, 42.
19 | Ministry of Environmental Protection and Green Transition 2025, 47.
20 | Andabaka, Beg & Gelo 2018, 115.
21 | Miketić-Curman 2020, 370.
22 | For example, Waste Framework Directive and Landfill Directive.

systems.[23] Local self-government units (cities and municipalities) are responsible for ensuring the implementation of national waste management measures within their jurisdiction, and, as some of them lack the institutional and financial capacity, cooperation between these units is often required.

A key requirement for the effective recovery and treatment of biodegradable waste also lies in the obligation of citizens to collect biodegradable waste separately.[24] Without this initial step, the quality of collected bio-waste is compromised, reducing its potential for material recovery, composting, or energy production. Therefore, citizens should be educated about the potential of biodegradable waste and the importance of its proper separation.

Croatian legal scholarship has historically devoted limited attention to waste management, with few comprehensive studies addressing its regulatory, institutional, or practical dimensions. Notably, in 2018, the Croatian Academy of Sciences and Arts organised a roundtable discussion titled 'Legal Regulation of Waste Management', which resulted in the publication of a volume containing several legal analyses on the subject.[25] Additionally, in 2020, another roundtable was held on 'Services of General Interest in EU Law and Policy and Their Impact on the Republic of Croatia', where some contributions addressed waste management within the broader context of public services.[26] Despite these efforts, comprehensive legal analyses of biodegradable waste remain scarce in Croatian academic literature. This paper aims to help fill that gap by contributing to the underdeveloped body of legal scholarship on this increasingly relevant environmental and regulatory issue.

Finally, a few key terminological considerations and concepts should be highlighted at the outset. The Croatian Waste Management Act[27] (WMA) distinctively defines biodegradable waste and bio-waste under the Waste Framework Directive and the Landfill Directive. It defines biodegradable waste correspondingly with the Landfill Directive as any waste or a part of waste subject to anaerobic or aerobic decomposition, such as garden waste, food waste, paper, and cardboard.[28] While paper and cardboard are commonly considered recyclable materials, they also qualify as biodegradable waste since they can naturally decompose. Conversely, bio-waste is defined in the WMA as in the Waste Framework Directive as biodegradable garden and park waste; food and kitchen waste from households, restaurants, caterers, and retail premises; and comparable waste from food processing facilities.[29]

23 | Boromisa, Golubovac & Vetma 2022, 2.
24 | Hadelan et al. 2024, 125.
25 | Ofak 2018, 39–74; Sarvan 2018, 97–144; Staničić 2018, 75–95; Turudić 2018, 157–170.
26 | Koprić 2021, 39–56; Škarica 2021, 73–101.
27 | Waste Management Act, Official Gazette (hereinafter: OG) no. 84/21 and 142/23.
28 | WMA, art. 4, para. 1, point 5.
29 | Ibid., point 3.

3. Legislation and achievement of targets in biodegradable waste management in Croatia

3.1. Pre-EU waste management legislation and achievements of biodegradable waste targets

Before joining the EU, Croatia's then-valid Waste Act[30] did not contain any provisions related to biodegradable waste. There was no specified limit on the maximum amount of biodegradable municipal waste that could be deposited in landfills each year. The activity of municipal-waste disposal was considered a communal service regulated by the Communal Services Act. As Škarica explains, the initial legal framework governing municipal-waste management was characterised by "ambiguous wording of the relevant provisions, the absence of adequate monitoring and evaluation mechanisms, and deficiencies in the oversight and sanctioning of unlawful practices".[31] Škarica also observed that the entire system was "highly decentralized, organizationally fragmented, and ineffective in achieving its proclaimed objectives."[32]

In October 2005, the Croatian Parliament passed the Waste Management Strategy,[33] with the aim of establishing a framework for sustainable waste management. The strategy included limited references to biodegradable waste within its proposed action measures. Specifically, it outlined the following action measures:

- The construction of composting facilities for biodegradable waste, complementing existing efforts in waste avoidance and separate collection and
- The promotion of biomass and biogas utilisation.[34]

Furthermore, waste management plans in municipalities and cities had the obligation to implement strategies for reducing the amount of biodegradable organic waste sent for disposal to achieve the goal of minimising overall waste quantities.[35]

After the Republic of Croatia gained independence in 1990, municipal-waste composition was not systematically monitored. The findings were limited to the results of individual tests conducted in a few areas. Thus, the baseline year for tracking progress towards reducing the proportion of biodegradable waste in municipal waste was 1997, when it was estimated that 1,015,000 tonnes of

30 | Waste Act, OG no. 178/04, 111/06, 60/08 and 87/09.
31 | Škarica 2021, 80.
32 | Ibid.
33 | Waste Management Strategy, OG no. 130/05.
34 | Waste Management Strategy, point 4.2.1.
35 | Ibid., point 4.5.

municipal waste were generated in the Republic of Croatia. Of that amount, 756,175 tonnes were estimated to be biodegradable waste.[36]

Based on the Waste Management Strategy, the Government of the Republic of Croatia adopted the Waste Management Plan for the Period 2007–2015 (hereinafter: WMP 2007–2015). According to this original Plan, decrease in the percentage of biodegradable waste in municipal waste was expected to be achieved through separate collection, composting, and processing at waste-management centres.[37] The construction of waste-management centres for the treatment of municipal waste was prioritised. However, the establishment of an effective waste-management system in Croatia has been hindered by the overly complex and fragmented territorial structure.[38] Two types of centres have been envisaged as part of the waste-management system: county centres and regional centres (i.e., a single centre shared by several counties).[39] The final decision depended on the concept selected by individual counties responsible for choosing locations for waste-management centres. Though activities for constructing waste-management centres were initiated in 2005, not a single centre had been built and made operational by 2015.[40]

3.2. Legislative developments and implementation of biodegradable waste targets after EU accession (2013–2021)

The Sustainable Waste Management Act (SWMA) was adopted in 2013 to harmonise Croatian legislation with the EU *acquis* in the field of waste management.[41] Under the SWMA, municipal waste was excluded from the scope of the Communal Services Act. Škarica noted an increased regulatory role of the national government and highlighted the following features of the new legal framework:

- The activities of local communities are prescribed by law as mandatory obligations, the non-fulfilment of which constitutes a misdemeanour.
- The tasks and powers of local governments are subject to sub-legislative regulation through governmental decrees and implementing regulations issued by the competent minister.

36 | Waste Management Plan for the Period 2007–2015, OG no. 85/07, point 4.3.2.
37 | WMP 2007–2015, point 5.2.2.
38 | A total of 555 units of local self-government have been established in Croatia (428 municipalities and 127 cities). Croatia has 20 counties (units of regional self-government). The City of Zagreb, as the capital of Croatia, has a special position as both a city and a county.
39 | WMP 2007–2015, point 5.6.
40 | The Waste Management Centre Marišćina started receiving waste for processing in February 2017, and Waste Management Centre Kaštijun has been in operation since March 2018.
41 | Sustainable Waste Management Act, OG no. 94/13, 73/17, 14/19, 98/19. The SWMA was in force from 23 July 2013 until 31 July 2021.

- For waste management plans adopted by local units, prior approval must be obtained from the administrative body of the regional self-government unit (i.e., the county).[42]

Furthermore, Croatia assumed certain limitations on waste disposal when it joined the EU in 2013. However, the EU granted it two derogations in the waste-management sector. The first derogation was related to the requirement to bring landfills for waste into compliance with the EU *acquis* by 1 January 2019. The second derogation, concerning the amount of biodegradable municipal waste sent to landfills, was granted until 1 January 2021.[43]

Under the SWMA, the maximum allowable mass of biodegradable municipal waste that may be deposited annually in all landfills was prescribed in relation to the mass of biodegradable municipal waste generated in 1997 as follows:

1. 75% or 567,131 tonnes by 31 December 2013
2. 50% or 378,088 tonnes by 31 December 2016
3. 35% or 264,661 tonnes by 31 December 2020.[44]

Operators have reported a total of 870,434 tonnes of biodegradable municipal waste in 2013.[45] Thus, the prescribed objective of reducing the landfilling of biodegradable municipal waste to 567,131 tonnes by 31 December 2013 was not met, as it was 53.48% above the required amount. In 2016, the amount of the disposed biodegradable municipal waste was 831,977 tonnes,[46] which exceeded the prescribed target of 378,088 tonnes by 120.05%. In 2020, the amount of disposed biodegradable municipal waste exceeded the prescribed goal by 331,352 tonnes, with a total of 596,013 tonnes being disposed of, compared to the goal of 264,661 tonnes.[47] It exceeded the required amount by 125.2%.

As the primary planning documents, the SWMA no longer prescribed the adoption of the Waste Management Strategy. Instead, its main content, including the evaluation of the current waste management situation, fundamental goals for managing waste, and guidelines for waste recovery and disposal in line with environmental and economic principles, was incorporated into the obligation for the Government of the Republic of Croatia to adopt the Waste Management Plan of the Republic of Croatia.

The deadline for adopting the Waste Management Plan expired on 31 December 2014. With a two-year delay, the Waste Management Plan of the Republic of Croatia

42 | Škarica 2021, 82.
43 | European Commission 2011, 22.
44 | SWMA, art. 24, para. 1.
45 | Environmental Protection Agency 2015, 36.
46 | Croatian Agency for the Environment and Nature 2017, 17.
47 | Ministry of Economy and Sustainable Development 2021, 18.

for the period 2017–2022 was adopted in 2017 (hereinafter: WMP 2017–2022).[48] It was amended once at the end of 2021.[49] The SWMA required each local self-government unit to adopt a waste-management plan, subject to the prior approval of the county's administrative body responsible for environmental protection. The City of Zagreb was obliged to obtain prior approval for the proposal of the waste-management plan from the Ministry responsible for environmental protection.[50] Each local self-government unit was also expected to adopt a decision on the manner of providing the public service of mixed municipal-waste collection and biodegradable municipal waste collection,[51] and decide on those who will collect mixed municipal waste and biodegradable waste.[52]

According to the WMP 2017–2022, separate bio-waste collection was implemented in only 34% of local self-government units.[53] This primarily involved bio-waste from gardens and public parks. The amount of bio-waste separately collected from households remained negligible. The most common method of managing this type of waste was still landfilling. Although the SWMA mandated local self-government units to collect bio-waste separately, the effects of this measure at the national level were minimal. Furthermore, considering the national target related to reducing biodegradable-waste disposal, the existing bio-waste treatment capacities at the household, local, and national levels were inadequate.[54]

In the total amount of the generated bio-waste, bio-waste from municipal waste constituted a significant share of around 87%. In 2021, only 25% of the bio-waste generated from municipal waste was collected separately.[55] The problem lies in the small number of local self-government units that collect bio-waste separately, the slow establishment of a bio-waste processing system, and insufficient investment in infrastructure for collecting and processing bio-waste separately.

As reasons for the failure to implement the SWMA, Škarica noted that the municipal waste-management system relies on the existing structure of local self-government, which includes 556 local units (429 municipalities, 126 cities, and the City of Zagreb).[56] This effectively means the creation of 556 potentially different waste-management regimes, as each local unit adopts its waste-management plan and decide on the conditions and methods of service provision.[57]

48 | WMP 2017–2022, OG no. 3/17.
49 | Amendment to the WMP 2017–2022, OG no. 1/22.
50 | SWMA, art. 21.
51 | SWMA, art. 30.
52 | Ibid., art. 31.
53 | WMP 2017–2022, point 3.4.1.
54 | Ibid.
55 | Ministry of Economy and Sustainable Development 2022, 21.
56 | Škarica 2021, 97.
57 | Ibid. For an examination of the complex relationships among stakeholders in the Republic of Croatia's waste management system, see Staničić 2018, 75–95.

Škarica further states that "such fragmentation of the system leads to the dissipation and inefficient use of resources for strategic planning, infrastructure development, and the procurement of necessary equipment for the provision of public services."[58] As a solution, Škarica proposed stronger territorial integration in the form of establishing areas comprising multiple local units, within which the regime for providing municipal waste-management services would be integrated.[59]

Škarica also pointed to the underutilization of oversight mechanisms and sanctions provided for in the SWMA.[60] The capacity of central government bodies to monitor and supervise such a large number of local self-government units is questionable. Owing to the lack of sanctions, many units have failed to fulfil their legally prescribed obligations for years. However, Škarica also posed doubts as to whether sanctioning local units for failing to meet their obligations would ensure the quality of municipal waste management services or whether such penalties would only further weaken local capacities.[61]

3.3. Newest waste management legislation from 2021 and the Waste Management Plan 2023–2028

Under the WMA, which is currently in force, the maximum allowed mass of biodegradable municipal waste that may be landfilled in a calendar year is 264,661 tonnes.[62] According to the latest available data, out of the 1,170,636 tonnes of biodegradable municipal waste produced in 2024, 502,752 tonnes were sent for disposal.[63] The desired target was once again missed, with the actual amount being 89.96% higher than the goal. Between 2020 and 2024, the number of composting facilities, the number of biogas plants processing municipal waste, and the amount of waste treated at these facilities increased, but all these remained below the level needed to make a substantial contribution toward achieving targets.[64]

The phased opening of waste-management centres helps reduce the amount of biodegradable municipal waste being disposed of, although the targets have not yet been fully met. Currently, of the 11 planned centres in Croatia, four waste centres have been built and are in operation (Marišćina, Kaštijun, Bikarac and Biljane Donje), four centres are under construction (Babina Gora, Lećevica, Lučino Razdolje and Piškornica), while the remaining three are in the project-documentation phase (Orlovnjak, Šagulje and Zagreb).[65]

58 | Škarica 2021, 97.
59 | Ibid.
60 | Ibid., 95.
61 | Ibid., 96.
62 | WMA, art. 55, para. 1.
63 | Ministry of Environmental Protection and Green Transition 2025, 25.
64 | Ibid., 28.
65 | Environmental Protection and Energy Efficiency Fund (no date).

Under the WMA,[66] the public municipal-waste-collection service, which includes the collection of bio-waste, remains under local self-government units. The executive bodies of a local self-government unit and the City of Zagreb are responsible for ensuring the provision of a quality, regular, and economically efficient public municipal-waste collection service within its territory. These bodies need to fulfil these responsibilities while avoiding high expenses, in accordance with the principles of sustainable development and environmental protection. Thus, the executive body must ensure public access to its operations. This includes guaranteeing the separate collection of mixed municipal waste from households and other sources, household bio-waste, recyclable municipal waste, hazardous municipal waste, and bulky household waste.[67] The public service provision area encompasses the territory of a local self-government unit and the City of Zagreb.[68] Further, the executive body should ensure that bio-waste is collected separately by providing one or more recycling yards or a mobile unit within its territory.[69] Several local self-government units may, by mutual agreement, jointly ensure the implementation of the obligation.[70]

Representative bodies of local self-government units must adopt decisions on the method of providing public services by 31 January 2022 and publish these details in their respective official gazettes and on their websites. The manner of public-service provision, including the criteria for calculating the amount of mixed municipal waste, the standard sizes and essential characteristics of waste collection containers, and the minimum frequency of waste collection by area must also be decided. The billing periods throughout the calendar year, the designated public-service provision area, and the mandatory minimum public-service fee must be defined and how these amounts were determined must be explained. Furthermore, the decision on regulating procedures for submitting and handling citizens' complaints related to the waste collection system, conditions for the individual use of public service, and the use of shared containers, must be adopted. The acceptable proof of service execution for personal users, the method for determining the share of service users in cases of shared container use by household users and other types of users where no agreement exists, provisions on contractual penalties, and the general terms and conditions for service users

66 | The newest WMA has not been amended to date. However, one of its provisions was subjected to constitutional review. The Croatian Constitutional Court, in its decision U-I-2934/2022 of 14 October 2023 (OG no. 142/23), repealed art. 72, para. 4 of the WMA. This provision had allowed imposing on all users of a shared waste container collectively for improper waste separation or disposal if an individual offender could not be identified. The Constitutional Court found such collective punishment as unconstitutional.

67 | WMA, art. 64, para. 4. If a local self-government unit or the City of Zagreb has not ensured the fulfilment of this obligation, it is liable for a misdemeanour.

68 | WMA, art. 64, para. 5.

69 | WMA, art. 84, para. 1. A violation of this obligation entails misdemeanour liability.

70 | WMA, art. 84, para. 5.

must be specified.[71] Additionally, provisions regarding the use of areas managed by local self-government units for bio-waste composting by service users must be determined.[72]

Under the criteria of WMA, amount of waste shall be calculated as the mass of handed-over mixed municipal waste during the billing period, expressed in kilograms or the volume of the mixed municipal waste container, expressed in litres, and the frequency of their emptying during the billing period.[73] Local self-government units are no longer obliged to adopt waste-management plans. The waste-management-planning documents include the Waste Management Plan of the Republic of Croatia, the waste management plans of the regional self-government units, and the waste management plan of the City of Zagreb (hereinafter: regional WMPs).[74] The newest Waste Management Plan of the Republic of Croatia for the period 2023–2028 (hereinafter: WMP 2023–2028) was adopted in June 2023.[75]

The regional WMPs must include information on the types and quantities of waste, on separately collected waste, landfilled municipal and biodegradable waste, the achievement of targets, and measures for the collection of mixed municipal waste and biodegradable municipal waste.[76] Most counties and the City of Zagreb did not adopt and publish the regional WMPs for the period 2023–2028 on time, which was a legal obligation by 1 January 2024. Draft plans of some counties for 2024–2029 are available, though they are in the adoption phase.[77]

The provisions of the WMA related to bio-waste can be divided into obligations that apply to waste producers, waste holders, and service users, as well as those that apply to service providers. To improve bio-waste management and reduce the share of bio-waste in the generated mixed municipal waste, the WMA prescribes a ban on mixing separately collected bio-waste with other types of waste.[78] There are general obligations regarding the separate collection of waste.[79] Within this general obligation, it is stipulated that the producer of bio-waste must either hand over the bio-waste separately from other types of waste to an authorized person or recycle it at the place of origin.[80] Violation of these obligations entails misdemeanour liability.

Bio-waste is collected separately as part of the public municipal waste collection service.[81] The user of the public service should either separately hand over the

71 | WMA, art. 66, para. 1.
72 | Ibid., para. 2. point 4.
73 | WMA, art. 67.
74 | WMA, art. 108.
75 | OG no. 84/23.
76 | WMA, Annex VI.
77 | Unfortunately, there is no centralised website where information can be accessed in one place. Momentarily, websites and official gazettes of all regional self-government units should be searched.
78 | WMA, art. 18, para. 4.
79 | WMA, art. 22.
80 | Ibid., para. 3.
81 | WMA, art. 69, para. 1., point 5. If the service providers fail to collect the content of a container from the service user, including separately collected biowaste, they are liable for a misdemeanour.

bio-waste or compost it at the place where it is generated.[82] The criteria for reducing the price of the public service should incentivize users to separate bio-waste from mixed municipal waste and, where applicable, to compost it.[83]

The WMA allows the legal person or sole trader to treat their waste without obtaining a waste-management permit, provided that they are original producers of the waste and treat bio-waste generated through their activity using biological treatment at the place of its generation. Further, the resulting product must not be placed in the market but used at the site where the waste was generated, and a report on this must be submitted to the Ministry competent for environmental protection by March 31 of the current year for the previous year.[84] The original producer of the waste, who is a natural person, may also treat their bio-waste without a permit, provided the treatment is done through biological aerobic processing (home composting).[85]

Intending to encourage waste prevention, the WMA permits the activation of economic instruments by the Ministry competent for the environment and the Environmental Protection and Energy Efficiency Fund, under the regulation governing state aid for waste management activities, which include:

- Recycling, including composting and anaerobic digestion of bio-waste, in a manner that ensures a high level of environmental protection and the product of such treatment meets high-quality standards
- Home composting and recycling of bio-waste and
- Promoting the use of materials made from bio-waste.[86]

Despite a noticeable increase in separately collected bio-waste during the implementation of the WMP 2017–2022 as a result of investments in the procurement and development of infrastructure for separate municipal waste collection and during the implementation of educational activities on the importance of separate collection of bio-waste, these efforts need to be continued in the upcoming planning period of 2023–2028. Further investment in bio-waste treatment capacities is also necessary.[87]

Among 18 active composting facilities in 2024, 15 were involved in treating municipal waste.[88] The year 2024 also marked a significant increase in the number of biogas plants processing municipal waste, reaching a total of 25 facilities.[89] Consequently, the volume of waste treated through anaerobic digestion noticeably

82 | WMA, art. 70, para. 4, point 8. If the service user has neither handed over the biowaste separately nor composted it at the place of its generation, they are liable for a misdemeanour.
83 | WMA, art. 73.
84 | WMA, art. 29, para. 2, point 2.
85 | Ibid., point 1.
86 | WMA, art. 99, para. 1, points 3–5.
87 | Amendment to the WMP 2017–2022, point 5.3.
88 | Ministry of Environmental Protection and Green Transition 2025, 47.
89 | Ibid., 48–49.

increased. However, since some counties do not have sufficient capacity or existing facilities are not sufficiently equipped for the use of separately collected bio-waste that is generated and will be generated during the planning period of 2023–2028, significant investments in infrastructure are required.[90] The planning of the system must be based on the 'proximity principle' to reduce environmental load and associated risks.[91] Coastal counties generally have limited capacities for composting and do not have biogas plants. Continental counties have moderate-to-limited capacities for composting, but only some have biogas plants. However, these capacities are not sufficient for future needs. To enable bio-waste processing, a composting plant should be built, especially in parts with a significant seasonal increase in municipal waste (coastal and island municipalities). This is particularly relevant to the establishment of composting facilities on islands and in areas that do not have these facilities.[92] Krk Island in Croatia is considered a model example of sustainable waste management on islands. In 2024, it became the first Zero Waste Island in Croatia and the second in the world.[93]

According to data for 2024, the largest amounts of municipal biodegradable waste were disposed of in Split-Dalmatia County (21.0%) and the City of Zagreb (15.7%).[94] This is largely attributed to high population density and significant tourism pressure, both of which contribute to increased waste generation, including biodegradable waste. Both regions also face challenges related to incomplete infrastructure and limited processing capacity for such waste. The operation of the Čret composting facility in Zagreb was suspended by the State Inspectorate in May 2024 because the permitted amount of the received waste exceeded.[95] Consequently, the costs of municipal services in Zagreb have increased as a result of the closure of the Čret facility and the implementation of a temporary solution involving cooperation with private companies.[96] In 2025, the City of Zagreb has initiated a project for a new Waste Management Centre in Resnik, which will include a facility for the biological treatment of separately collected bio-waste. As of summer 2025, the project is undergoing public consultation as part of the environmental-impact-assessment process.[97] The closure of the existing Jakuševec landfill and the trial operation of the new Waste Management Centre are planned for late 2028.

To conclude, in the context of improving bio-waste management in the Republic of Croatia, several strategic measures have been outlined in the WMP 2023–2028. One of the primary measures focuses on enhancing the system for the separate collection of municipal waste, alongside the development and

90 | WMP 2023–2028, point 8.2.2.
91 | Ibid.
92 | WMP 2023–2028, point 3.
93 | Zero Waste Europe 2024.
94 | Ministry of Environment and Green Transition 2025, 46.
95 | Croatian Radiotelevision 2024.
96 | Zagreb Holding Ltd. 2025, 10.
97 | City of Zagreb 2025.

modernisation of infrastructure, particularly those dedicated to the biological treatment of separately collected bio-waste.[98] These investments are designed to support a circular-economy approach and promote increased resource efficiency. Another significant measure is the emphasis on raising public awareness, disseminating information, and providing education on waste and product management. Targeted communication campaigns are planned to highlight the significance and benefits of separate bio-waste collection and the use of compost, thereby fostering behavioural change and public participation in sustainable waste-management practices.[99]

To further encourage the application of the waste-management hierarchy, the Croatian Government has officially introduced a fee for waste disposal by decree, effective as of 1 January 2025.[100] This economic instrument is expected to stimulate local self-government units to intensify their efforts in waste separation and recovery, focusing on increasing the quantities of the separately collected and processed bio-waste. The fee for waste disposal (landfill fee) should have already been introduced in Croatia, according to the previously valid SWMA. However, its application was delayed for years owing to the failure to pass a by-law that would determine the method of calculation and the amount of the fee, though the law provides for this.

Finally, the WMP 2023–2028 also includes measures to prevent bio-waste. A first key measure is strengthening policy frameworks for avoiding food waste. This initiative is being implemented through the Food Waste Prevention and Reduction Plan for the period 2023–2028, which builds upon strategic efforts to increase food donations, reduce food waste, and enhance food security for vulnerable population groups.[101] Another critical measure is promoting household composting systems.[102] It aims to encourage households to compost bio-waste using their composters, thereby producing free organic fertilisers and reducing the need to purchase commercial fertilisers. Since the feasibility of household composting depends on the availability of space for using the produced compost, this measure primarily targets rural areas and suburban zones with a high number of single-family homes with gardens. The third measure focuses on improving bio-waste data monitoring systems.[103] Its goal is to enhance the existing system

98 | WMP 2023–2028, point 12.1, measure 1.
99 | Ibid., measure 2.
100 | Decree on the Unit Fee for Waste Disposal, OG no. 137/24. The Decree stipulates a gradual increase in the landfill fee, starting at €30 per tonne in 2025 and rising to €50 per tonne by 2029 and beyond. The liable entity for payment is the legal person managing the landfill, and the fee has to be paid to the Environmental Protection and Energy Efficiency Fund. Exceptions to the unit fee apply in the following cases, where the fee is set at €0.00 per tonne: waste disposed of at a landfill that is part of an integrated waste-management centre and asbestos-containing waste disposed of in designated cells (cassettes) within landfills.
101 | WMP 2023–2028, point 15.6, measure 2.
102 | Ibid., measure 4.
103 | Ibid., measure 3.

for measuring the quantities of bio-waste generated at the national level and to establish a mechanism for tracking the amount of bio-waste prevented through household composting.[104]

4. Success stories and case studies in biodegradable-waste management in Croatia

4.1. Public awareness initiatives and financial instruments

The separate collection of biodegradable waste in Croatia was introduced through several phases. Under the SWMA, local self-government units must ensure the collection of biodegradable municipal waste within their jurisdiction, as this service was considered of general public interest. Based on the SWMA, the Government adopted the Decree on Municipal Waste Management with a three-year delay.[105] This regulation required local self-government units to adopt decisions on the methods for collecting mixed and biodegradable waste.[106] In the following years, the practical 'door-to-door' separation and collection of waste was initiated, including the distribution of brown coloured waste bins for bio-waste to households.[107] Some cities provided home composters to those who declared that they would rather manage their bio-waste through home composting. For the purpose of this article, decisions on the provision of public municipal waste collection services were analysed in more than half of the cities in Croatia. These decisions also include initiatives for the separate collection of biodegradable waste.[108] It may be reasonable to assume that the remaining cities also employ similar initiatives. The following sections will discuss the best practices in public-awareness initiatives identified through the analysis.

To introduce the system of separate waste collection to citizens and raise awareness about the importance of separation and recycling, numerous campaigns and educational public forums were organised. Few cities introduced

104 | The Waste Management Ordinance (OG no. 106/22 and 138/24) prescribes the obligation to monitor the quantities of bio-waste avoided through household composting (art. 36, para. 8).
105 | Decree on Municipal Waste Management, OG no. 50/17, 84/19, 14/20 and 31/21.
106 | Decree on Municipal Waste Management, art. 4.
107 | There are brown waste bins for biowaste, yellow bins for plastic, blue bins for paper, and green bins for mixed waste.
108 | Analysed cities were: Bakar, Beli Manastir, Belišće, Benkovac, Biograd na Moru, Bjelovar, Buje, Buzet, Cres, Crikvenica, Čabar, Čakovec, Čazma, Daruvar, Delnice, Donja Stubica, Donji Miholjac, Drniš, Dubrovnik, Duga Resa, Dugo Selo, Đakovo, Đurđevac, Garešnica, Glina, Gospić, Grubišno Polje, Hrvatska Kostajnica, Hvar, Ilok, Imotski, Ivanec, Ivanić-Grad, Jastrebarsko, Karlovac, Kastav, Kaštela, Klanjec, Knin, Komiža, Korpivnica, Korčula, Kraljevica, Krapina, Križevci, Krk, Kutina, Kutjevo, Labin, Lepoglava, Lipik, Ludbreg, Makarska, Mali Lošinj, Metković, Mursko Središće, Našice, Nin, Nova Gradiška, Novalja, Novigrad, Novi Marof, Novi Vinodolski, Novska, Obrovac, Ogulin, Omiš, Opatija, Opuzen, Orahovica, Oroslavlje, Osijek, and Zagreb.

separate initiatives specifically for composting and biodegradable waste. However, educational guidelines and projects on biodegradable waste were mainly part of a broader framework, the general education on waste separation and recycling. Campaigns would usually have a rhymed slogan such as "Odgovoran budi, odvajat se potrudi" ("Be responsible, sort —it is possible"),[109] and would include some of the following components:

- Public lecture on sustainable waste management—usually held to inform and educate citizens about sustainable waste management
- Educational flyers and brochures—in physical and digital form, often distributed with the invoice for waste services, containing instructions, among others, on the disposal of biodegradable waste and composting
- Education conducted in kindergartens, primary schools and high schools, which included theatrical performances, mascots, picture books, quizzes, and games
- Informative articles—published on the official websites of cities and companies responsible for waste collection
- Television spots and
- Online platforms and phone applications.

Besides these measures, citizens are also encouraged to separate waste and compost it through financial incentives. Namely, according to principle "pay as you throw," the public-service fee for waste collection is fixed as the price of the mandatory minimum public service and the price of the service corresponding to the quantity of mixed municipal waste delivered (the latter consist of the price for emptying a specific volume of a mixed municipal-waste container, number of times the bin/container was emptied per month, and the share of the user in the use of the container).[110] In other words, the service fees are higher as the amount of mixed waste increases. Therefore, to lower the costs, citizens should separate their waste and minimise mixed municipal waste. The fee paid by citizens covers only the collection, processing, and disposal of mixed municipal waste. The collection and disposal of all other types of waste, such as biodegradable waste, are provided free of charge.

Cities have decided to adopt additional financial measures to encourage the separation of biodegradable waste. The negative one represents the monetary penalty. Citizens should deliver bio-waste (using brown bins) separately or compost it. In the event of a violation, a penalty is imposed. The maximum penalty represents the annual fee for the mandatory public service. Interestingly, 'contractual penalty' was once a part of the public-service fee for waste collection. However,

109 | This slogan is part of a campaign in the city of Hvar and aims to minimise waste production and educate citizens about waste as a valuable resource.
110 | Decision on the Method of Providing the Public Service of Municipal Waste Collection in the Area of the City of Koprivnica, Gazette of the City of Koprivnica no. 1/22.

the Constitutional Court of the Republic of Croatia ruled that such practice did not follow the provisions of the then applicable SWMA.[111] Information on imposed penalties is not systematically published or publicly accessible and is available only through occasional media reports. This suggests a lack of transparency and may also indicate shortcomings in the enforcement of waste-separation obligations. Nonetheless, as previously noted, the absence of adequately developed waste management infrastructure raises important concerns about the effectiveness and fairness of punitive measures.

Positive measures represent the criteria for reducing the monthly invoice. Using smaller volume bins for mixed municipal waste implies a greater volume of separately collected bio-waste and recyclable municipal waste.[112] Other criteria include having a house composting system or using composting facilities. Home composters were freely distributed to interested citizens, and instructions were provided to them on how they can build a compost site themselves. In some decisions, exact guidelines regarding the placement of compost sites were prescribed: "home composting of bio-waste must be done at a distance of at least 2 meters from the cadastral plot border, unless the user has a consent of the neighbouring landowner to compost at a shorter distance".[113] In 2024, 18 composting facilities were made available to citizens. Additionally, the Croatian Composting Plants Association was founded with the aim of promoting composting as the best environmentally friendly method for managing biodegradable waste, educating citizens and legal entities, and supporting the development of local composting facilities and initiatives.[114]

4.2. Best practices for biodegradable waste management

In recent years, Croatia has made significant progress in managing biodegradable waste. By examining case studies and the adopted strategies, we aim to uncover key factors behind this progress. Among the leading examples in positive waste management is the city of Osijek, which is the fourth city in the country in terms of waste separation (57,97%).[115] Interestingly, Osijek was the first city to implement

111 | The Croatian Constitutional Court, in its Decision U-II-2492/2017 et al. of 23 March 2021 (OG no. 31/21), inter alia, repealed the parts of the Decree on Municipal Waste Management (OG no. 50/17 and 84/19) that referred to the pricing of the contractual penalty. The Constitutional Court held that, although the Decree prescribed the obligation of public service users to act in accordance with the law, and their responsibility for handling waste and containers, it nonetheless follows that the manner in which the contractual penalty was prescribed as part of the public service fee structure, was not in accordance with the powers granted to the Croatian Government under the SWMA (point 28.2. of the Decision).

112 | Bin volumes are: 80, 120, 240 and 360 litres.

113 | Decision on the Method of Providing the Public Service of Municipal Waste Collection in the Area of the City of Slatina, Gazette of the City of Slatina, no. 7/23.

114 | Croatian Composting Plants Association, https://ccpa.hr/.

115 | Ministry of Environment and Green Transition 2025, 62.

the separate collection of biodegradable waste in multi-residential buildings, using specially designed containers called 'Organko'. These small containers, with a 16-litre volume, were designed for the pre-composting process directly within the home. When they are filled, waste can be placed in brown bins outside the building. Once a week, workers collect it and transport it to a composting facility.[116] In 2021, an agreement was signed to transport daily bio-waste generated at the main marketplace directly to the composting facility. Compost thus produced was distributed to the public, especially local family farms. To celebrate their success, last year, Osijek hosted the first Eco City Waste Fest, where citizens were educated about waste management in an entertaining manner.

Another positive example is the city of Daruvar, whose citizens play a key role in promoting sustainable waste management. During food preparation, organic waste is placed into specially made brown bins of 10-litre capacity, marked with the slogan, "Let's separate bio-waste for more beautiful Daruvar". Additionally, they use certified biodegradable and compostable bags that are compatible with bins.[117] Collected bio-waste is then transferred to the compost facility, and the produced compost is used in public parks and gardens. According to a study, over the three years since the introduction of separate bio-waste collection, there was a 42.57% reduction in the amount of waste sent to landfills.[118] Reducing pressure from landfills and minimising greenhouse gas emissions is a key objective of sustainable waste management.

Prelog city is one of the most successful Croatian examples in terms of waste separation, achieving a rate of over 60%, primarily because of the high level of public awareness and cooperation with the municipal utility company PRE-KOM ltd. As a part of the 'door-to-door' system, the separate collection of biodegradable waste began in 2015.[119] In the same year, a composting facility called 'Prelog' was also opened, from which citizens received an annual coupon for two bags of compost as a reward for their efforts in separating bio-waste.[120] In their monitoring system, the company uses yellow and red cards as a warning for the improperly sorted waste to educate and alert citizens, rather than imposing penalties on them. Eventually, in cases of repeated or intentional violations, a fine is issued.[121] Educating citizens to separate waste and recycle it is another remarkable point. Various mechanisms are used for educational purposes, including promotional materials, public forums, lectures and quizzes targeting kindergartens and schools, as well as web pages, social media platforms, and mobile applications.[122] Despite having

116 | Unikom 2018.
117 | List & Djedović 2024, 125.
118 | Ibid.
119 | Zero Waste Cities 2020.
120 | Ibid.
121 | Ibid.
122 | Ibid.

achieved significant success, the city expands its activities in alignment with the 'zero waste' strategy. Some of the goals set for 2025 are: to separate up to 75% of recyclable waste, which will be processed and reused through sustainable methods such as recycling, composting, anaerobic digestion and others, and to encourage composting and the use of the final product for agricultural purposes.[123]

A key success of the city of Koprivnica in waste management lies in the modern composting facility 'Herešin' which ensures proper treatment of collected biodegradable waste from the city's green areas and households.[124] Its first-class compost called 'Domko' is produced in 6-to-8 weeks, which is relatively shorter than the usual 6-month period. Altogether, there are six cycles of composting in a year, with 1,500 tonnes of processed bio-waste per cycle.[125] Before the final compost is distributed, a sample is sent to the laboratory for quality control. Additionally, a third-class compost is also produced and used to enhance soil quality.

Household bio-waste, along with other organic materials such as tree branches or animal manure, can be used as a biomass suitable for the production of biogas that can be used for heating and electrical needs, and as a byproduct, produces a valuable digestate.[126] In Croatia, the Slavonia and Baranja regions have the highest number of biogas plants linked to a strong agricultural base and the availability of organic-waste materials.[127] One notable example is the biogas plant 'Hrastin', which was constructed within six months in 2018, producing both electricity and thermal energy. The generated electricity is used in the Croatian power grid, increasing the share of renewable energy. Various forms of biodegradable waste, including agricultural crop waste, animal manure, and organic waste are utilised in the plant. Besides its energy output, the plant also plays a socio-economic role in the local community, providing new employment opportunities and addressing the need for waste materials from local farms and households.[128] The latter is aligned with the principles of the circular economy.

In recent years, Croatia has implemented a specific waste prevention measure to reduce food-waste generation. Approximately 286,379 tonnes of food waste were generated in 2020, with 40% being avoidable.[129] The measure includes a national policy framework[130] and a series of campaigns under the slogan "Food is not waste", aiming to transform public perception of food, reduce food waste at all levels—from households to institutions, and achieve a 30% reduction in food waste by the end of 2028. It also aims to encourage food donations and redistributions

123 | GKP PRE-KOM D.O.O. 2022.
124 | Hadelan et al. 2024, 132.
125 | Ibid, 133.
126 | Ošlaj & Muršec 2010, 110.
127 | Ministry of Economy and Sustainable Development 2023, 8.
128 | Osijek-Baranja County 2018.
129 | European Environment Agency 2024, 15.
130 | Food Waste Prevention and Reduction Plan of the Republic of Croatia for the period 2023 to 2028, OG no. 156/22.

and prevent food-waste generation using composting sites or biogas treatment. Food disposal should be the last resort.[131] For this purpose, animated films and picture books for children were created, professional conferences were held, and an online platform was established to serve as a space for the exchange of knowledge and best practices.[132] Additionally, a food-donation system was established, including an online platform e-donations, governed by the Ministry of Agriculture, Forestry, and Fisheries.[133] In 2021, a campaign was conducted to raise awareness about understanding food date labelling and teaching differences among the types of date labels. Misunderstanding about these labels is considered a reason for the unnecessary disposal of safe-to-consume food.

In 2021, a pilot project was launched in three hotels with the goal of implementing work practices in hotel kitchens and reducing bio-waste, specifically food waste. Workers were introduced to the principles of planned food management, proper food storage, and realistic meal portion estimation. The planned goal of reducing food waste by at least ten per cent was achieved, thereby also decreasing the negative environmental impact of hotels and their share in bio-waste generation.[134]

4.3. Identified risks and mitigation measures

Despite its potential as a valuable resource for energy and electricity production and composting, biodegradable waste still faces several environmental, economic, and social challenges and risks. According to the National Report, 1,170,636 tonnes of biodegradable municipal waste were produced in 2024, but 502,752 tonnes ended up in landfills.[135] Although the waste separation rate has increased compared to previous years, the current level remains below targeted thresholds. Separate collection was implemented in all counties; however, it was done on the territory of 277 local self-government units (cities and municipalities), representing 50% of all local self-government units in the country.[136] Croatia also faces a significant lack of infrastructure and capacity for the effective treatment of biodegradable waste in many regions, especially tourist regions during the summer months, when the generation of biodegradable waste increases owing to a large number of visitors. This places additional pressure on local waste-management systems.

Biodegradable waste that ends up in landfills poses environmental risk, as some landfills operate without proper gas or leachate management.[137] As stated

131 | Ministry of Economy and Sustainable Development 2024, 7.
132 | Ministry of Agriculture, Forestry and Fisheries, *Food is Not Waste*, https://hrana-nije-otpad.mps.hr/.
133 | Ibid., *e-Donating*, https://poljoprivreda.gov.hr/e-doniranje/3909.
134 | Ministry of Tourism and Sport 2022.
135 | Ministry of Environment and Green Transition 2025, 45.
136 | Ibid., 7.
137 | Presečki 2023.

before, during its decomposition, harmful gases are released into the atmosphere; mould, viruses, and bacteria spread; and drainage liquids pollute groundwater. Additionally, nuisances such as odours and the presence of insects, birds, and rodents occur.[138] Aforementioned is especially a problem in several thousand illegal landfills in Croatia, but it has also been observed in urban areas where waste containers are frequently left open. As a preventive measure, cities typically schedule deratization twice a year with additional required interventions.

Citizens living near composting sites and biogas plants frequently complain of unpleasant odour. The issue of odours also arises from contaminated bio-waste—from improperly separated waste at the source, which complicates the recovery process. In 2024, several hundred citizens protested in front of the composting site in Zagreb owing to the odour, demanding the revocation of the permit that allows the transport of bio-waste to the site. Being unable to open windows and to let children play outdoors, they called for urgent action.[139] This problem is a consequence of inadequate infrastructure and poor waste-management practices, as certain facilities receive larger amounts of biodegradable waste than initially planned or permitted.

An additional problem is the accumulation of unsold compost that is eventually stored in facility areas. The latter is caused by the lack of a regulatory framework governing fertiliser products, which prevents the classification and distribution of compost as a high-quality fertiliser. A forthcoming Ordinance on HR fertilising products, which is expected to regulate this area, underwent public consultation in April 2025, though the Committee responsible for drafting the ordinance was established in summer 2024. Meanwhile, while the Ordinance has yet to enter into force, facilities face financial and operational losses. Economic losses associated with unsold compost are estimated at approximately €2.1 million. Furthermore, additional costs arise from the storage and maintenance of compost quality.[140] On the operational side, the reduction in storage capacity prevents the acceptance of new bio-waste, slowing the development of the circular economy.

Another challenge for biogas plants is their susceptibility to market fluctuations. For example, the war in Ukraine led to a significant increase in the prices of raw materials used by plants. Further, the EU introduced a regulation capping the electricity market price at €180 per megawatt-hour.[141] As a result, owing to incurred losses, several plants shut down while some of them decided to terminate their contracts with the Croatian Energy Market Operator (HROTE). After market conditions stabilised, the plants attempted to renew contracts but were initially not permitted. Later, they were allowed to renew the contracts only for the remaining

138 | Barčić & Ivančić 2010, 349.
139 | N12024.
140 | TehnoEko 2025.
141 | Council Regulation (EU) 2022/1854 of 6 October 2022 on an emergency intervention to address high energy prices, OJ L 261I, 7.10.2022.

duration specified in the first contracts that were terminated and only upon the payment of a substantial fee.[142]

To improve biodegradable waste management, Croatia needs to establish a significantly higher number of composting facilities and biogas plants for treating biodegradable waste. However, the selection of new sites faces difficulties owing to public mistrust, the 'not in my backyard' (NIMBY) syndrome, and insufficient public participation in decision-making processes.[143] Therefore, further public-education initiatives and financial investments in infrastructure are crucial to raising awareness of the environmental and economic benefits of biodegradable waste management.

5. Conclusion

The transformation of biodegradable-waste management in Croatia presents a complex challenge, shaped by evolving EU legislation, national legislative reforms, infrastructural limitations, and socio-political dynamics. Despite notable progress since the country's accession to the EU, Croatia faces significant obstacles in aligning its biodegradable waste management practices with EU targets and sustainability principles. The pre-accession period laid the groundwork for a structured approach to waste management, with the 2005 Waste Management Strategy and the WMP 2007–2015 emphasising the development of waste treatment infrastructure. However, the fragmented territorial organisation and delayed implementation of key measures hindered the establishment of a coherent and effective system. The adoption of the SWMA in 2013 marked an important step in harmonising national legislation with the EU *acquis*. Yet, the persistent failure to meet prescribed targets, such as the thresholds for landfill disposal of biodegradable waste, highlights the gap between legislative intent and practical execution.

The WMP 2017–2022 introduced essential measures, which led to an increase in the separate collection of bio-waste. However, the slow pace of infrastructure development, particularly the limited number of operational composting facilities and biogas plants, undermines national efforts. Until 2025, only four of the eleven planned waste management centres have been operational. The most recent legislative and policy developments, including the WMP 2023–2028 and the introduction of a landfill fee in 2025, signal a renewed commitment to improving the management of biodegradable waste. These measures are expected to incentivise local self-government units to enhance separate collection and invest in treatment capacities. Nevertheless, the success of these initiatives will depend on overcoming

142 | OIE Hrvatska 2024.
143 | Boromisa, Golubovac & Vetma 2022, 14.

persistent structural and behavioural barriers, including the lack of adequate infrastructure in many regions, particularly in tourist-heavy areas during peak seasons.

Public engagement remains a critical factor. The NIMBY syndrome and general mistrust toward waste-treatment facilities impede the siting of new infrastructure. Therefore, sustained public-education campaigns and transparent decision-making processes are crucial for fostering trust and encouraging community participation. Additionally, the forthcoming Ordinance on HR fertilising products must be enacted without further delay to enable the classification and distribution of compost, thereby reducing financial losses for treatment facilities and promoting circular-economy principles.

This paper has demonstrated that legal harmonisation with the EU *acquis* is insufficient without parallel investment in infrastructure and public support. It outlines the evolution of legislation and policy implementation in Croatia's biodegradable waste management sector, including examples of best practice. Such an analysis has not previously been undertaken in the legal literature. Further empirical research is needed to evaluate the effectiveness of these policies at the local level. In particular, the role of penalty-based enforcement in promoting the separation of biodegradable waste should be examined more closely. However, given the current lack of treatment capacities, the actual effectiveness and overall impact of these measures remain uncertain.

Additionally, a critical *de lege ferenda* issue relates to the timely adoption of regional WMPs, which are legally required under national legislation. Most counties and the City of Zagreb failed to adopt and publish their regional WMPs for 2023–2028 by the statutory deadline of 1 January 2024. This non-compliance can be understood as a spillover effect of the delayed adoption of the national WMP 2023–2028 officially adopted only on 28 June 2023. The late publication of the national plan reduced the time available to regional self-government units for alignment and procedural adoption. To ensure effective implementation of national waste-policy goals and compliance with EU directives, all regional WMPs should be adopted and operationalised in a speedy manner.

In conclusion, while Croatia has made notable progress in biodegradable-waste management, the road to its full compliance with EU directives and a sustainable, circular economy remains a long one. A coordinated approach combining legislative enforcement, infrastructure investment, and public education is required to achieve these goals. Only through such an integrated strategy can Croatia effectively transform its biodegradable-waste management system and make meaningful contributions to broader environmental and climate objectives.

Reference list

1. Andabaka A, Beg M & Gelo T (2018) Challenges of Circular Economy in Croatia, *International Journal of Multidisciplinarity in Business and Science* 4(5), pp. 115–126, https://doi.org/10.56321/ijmbs
2. Barčić D & Ivančić V (2010) Impact of the Prudinec/Jakuševec Landfill on Environmental Pollution, *Šumarski list* 7–8, CXXXIV, pp. 347–359, https://doi.org/10.31298/sl
3. Boromisa A, Golubovac N, & Vetma N (2022) Governance of the Waste Management in Croatia, *Journal of Legal, Ethical and Regulatory Issues* 25(S4), pp. 1–18, https://www.abacademies.org/articles/governance-of-the-waste-management-in-croatia.pdf [10.06.2025]
4. City of Zagreb (2025*) Počinje javna rasprava o Studiji o utjecaju na okoliš za Centar za gospodarenje otpadom Zagreb*, 17 July, https://zagreb.hr/pocinje-javna-rasprava-o-studiji-o-utjecaju-na-oko/210164 [21.07.2025]
5. Croatian Agency for the Environment and Nature (2017) *Izvješće o komunalnom otpadu za 2016. godinu*, https://isgo-portal.mingor.hr/hr/izvjesca/izvjesca-o-komunalnom-otpadu [15.06.2025]
6. Croatian Radiotelevision (2024) *Državni inspektorat zatvorio zagrebačku kompostanu "Čret" na Markuševcu*, 14 May, https://vijesti.hrt.hr/hrvatska/drzavni-inspektorat-zatvorio-zagrebacku-kompostanu-cret-na-markusevcu-11538644 [21.07.2025]
7. Environmental Protection Agency (2015) *Izvješće o komunalnom otpadu za 2013. godinu*, https://www.haop.hr/sites/default/files/uploads/dokumenti/021_otpad/Izvjesca/komunalni/OTP_Izvje%C5%A1%C4%87e%20o%20komunalnom%20otpadu_2013..pdf [15.06.2025]
8. Environmental Protection and Energy Efficiency Fund (no date) *Waste management centres*, https://www.fzoeu.hr/en/waste-management-centres-7593 [15.06.2025]
9. European Commission (2011) *Information on the Results of the EU Accession Negotiations with Croatia*, https://mvep.gov.hr/UserDocsImages/custompages/static/hrv/files/pregovori/111123-Elarg-info-EN.pdf [15.06.2025]
10. European Commission (2020) *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on an EU strategy to reduce methane emissions*, COM(2020) 663 final

11. European Environment Agency (2024) *Waste prevention country profile Croatia*, December, https://www.eea.europa.eu/en/topics/in-depth/waste-and-recycling/country-profiles-on-waste-prevention-2025/croatia_waste-prevention-factsheet-2024/@@download/file [15.06.2025]

12. European Environment Agency (2025) Municipal waste landfill rates in Europe by country, 17 December, https://www.eea.europa.eu/en/analysis/y/diversion-of-waste-from-landfill/municipal-waste-landfill-rates [15.06.2025]

13. Eurostat (2025) *Municipal waste down by second consecutive year*, 13 February, https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20250213-1 [15.06.2025]

14. Fuk B (2020) Biootpad u vrijeme krize, *Sigurnost* 62(3), pp. 303–307, https://doi.org/10.31306/s

15. GKP PRE-KOM D.O.O. (2022) *Ciljevi "ZERO WASTE" JLS-ova do 2025. godine*, 1 October, https://www.pre-kom.hr/zero-waste-2025.html [15.06.2025]

16. Hadelan L, Nekret-Katić E, Zrakić Sušac M & Grubačević S (2024) Kompostiranje kao sastavnica kružnog gospodarstva: iskustva Kompostane Herešin, *Agroeconomia Croatica* 14:2024 (1), pp. 124–137, https://doi.org/10.69680/ac

17. Kantar S, Puljiz M, Svržnjak K & Vidović Krušić M (2024) Gospodarenje biootpadom na području grada Križevaca, *Agroeconomia Croatica* 14(1), pp. 73–82, https://doi.org/10.69680/ac

18. Koprić I (2021) Lokalne javne službe u vrtlogu europeizacije, in: Barbić J (ed.) *Službe od općeg interesa u pravu i politici Europske unije i njihov utjecaj na Republiku Hrvatsku*, Zagreb, Hrvatska akedmija znanosti i umjetnosti, pp. 39–56

19. List M & Djedović I (2024) Uloga odvojenog prikupljanja biootpada u održivom razvoju: Primjer Grada Daruvara, *Agroeconomia Croatica* 14(2), pp. 123–137, https://doi.org/10.69680/ac.14.2.12

20. Miketić-Curman S (2020) Primjena koncepta kružnog gospodarstva i industrijske ekologije kao doprinos održivom razvoju i zaštiti okoliša, *Sigurnost* 62(4), pp. 369–375, https://doi.org/10.31306/s

21. Ministry of Agriculture, Forestry and Fisheries (no date) *e-Donating*, https://poljoprivreda.gov.hr/e-doniranje/3909 [15.06.2025]

22. Ministry of Agriculture, Forestry and Fisheries (no date) *Food is Not Waste*, https://hrana-nije-otpad.mps.hr/ [15.06.2025]

23. Ministry of Economy and Sustainable Development (2021) *Izvješće o komunalnom otpadu za 2020. godinu*, https://isgo-portal.mingor.hr/hr/izvjesca/izvjesca-o-komunalnom-otpadu [15.06.2025]

24. Ministry of Economy and Sustainable Development (2022) *Izvješće o komunalnom otpadu za 2021. godinu*, https://isgo-portal.mingor.hr/hr/izvjesca/izvjesca-o-komunalnom-otpadu [15.06.2025]

25. Ministry of Economy and Sustainable Development (2023) *Izvješće o bioplinskim postrojenjima iz baze podataka Registra onečišćavanja okoliša Republike Hrvatske (ROO) za razdoblje 2017. – 2021. godine,* https://www.haop.hr/sites/default/files/uploads/dokumenti/022_reg_oneciscivaca/Izvjesca/Izvje%C5%A1%C4%87e_Bioplinska%20postrojenja_2017-2021.pdf [15.06.2025]

26. Ministry of Economy and Sustainable Development (2024) *Otpad od hrane i preporuke za sprječavanje nastanka otpada od hrane u poslovnom sektoru: Unaprjeđenje podataka o otpadu od hrane u Republici Hrvatskoj (HRFWD – Improvement of Data on Food Waste in Croatia),* https://isgo-portal.mingor.hr/sites/default/files/dokumenti/2025-01/D2_3-Brochure_compressed.pdf [15.06.2025]

27. Ministry of Environmental Protection and Green Transition (2025) *Nacionalno izvješće o komunalnom otpadu za 2024. godinu*, https://isgo-portal.mingor.hr/hr/izvjesca/izvjesca-o-komunalnom-otpadu [15.06.2025]

28. Ministry of Tourism and Sport (2022) *Završio pilot projekt "Smanji otpad od hrane, kuhaj za svoje goste"*, 11 July, https://mint.gov.hr/odrzivi-turizam-22984/zavrsio-pilot-projekt-smanji-otpad-od-hrane-kuhaj-za-svoje-goste/23189 [15.06.2025]

29. N1 (2024) *Zagrepčani prosvjedovali zbog kompostane, oglasio se Tomašević*, 16 April, https://n1info.hr/vijesti/zagrepcani-prosvjedovali-zbog-kompostane-oglasio-se-tomasevic/ [15.06.2025]

30. Ofak L (2018) Pouke za Hrvatsku iz prakse Suda Europske unije u području gospodarenja otpadom, in Barbić J (ed.) *Pravno uređenje gospodarenja otpadom*, Zagreb, Hrvatska akedmija znanosti i umjetnosti, pp. 39–74

31. OIE HRVATSKA (2024) *Birokratska greška državne energetske agencije: Vlasnici bioplinskih postrojenja pripremaju tužbe protiv HERA-e,* 20 June, https://oie.hr/birokratska-greska-drzavne-energetske-agencije-vlasnici-bioplinskih-postrojenja-pripremaju-tuzbe-protiv-hera-e/ [15.06.2025]

32. Osijek-Baranja County (2018*) "Bioplinsko postrojenje Hrastin" uspješan projekt i primjer dobre prakse*, 22 November, https://obz.hr/index.php/k2-listing/item/550-bioplinsko-postrojenje-hrastin-uspjesan-projekt-i-primjer-dobre-prakse [15.06.2025]

33. Ošlaj M & Muršec B (2010) Biogas as a Renewable Energy Source, *Technical Gazette* 17(1), pp. 109–114, https://doi.org/10.17559/TV

34. Petravić-Tominac V, Nastav N, Buljubašić M & Šantek B (2020) Current State of Biogas Production in Croatia, *Energy, Sustainability and Society* 10(8), pp. 1–10 https://doi.org/10.1186/s13705-020-0243-y

35. Presečki I (2023) Current Challenges in Croatian Waste Management, presentation, in: *Intelligent Waste Management in Croatia*, University of Zagreb, Zagreb, 30 November 2023, https://www.advantageaustria.org/hr/Ivana_Presecki.pdf [15.06.2025]

36. Sarvan D (2018) Obveze Republike Hrvatske u održivom gospodarenju komunalnim otpadom prema Ugovoru o pristupanju Europskoj uniji, in Barbić J (ed.*) Pravno uređenje gospodarenja otpadom*, Zagreb, Hrvatska akedmija znanosti i umjetnosti, pp. 97–144

37. Škarica M (2021) Javne usluge u sustavu gospodarenja komunalnim otpadom u Hrvatskoj: Europski standardi i lokalna prilagodba, in: Barbić J (ed.) *Službe od općeg interesa u pravu i politici Europske unije i njihov utjecaj na Republiku Hrvatsku*, Zagreb, Hrvatska akedmija znanosti i umjetnosti, pp. 73–101

38. Staničić F (2018) Dionici u procesu gospodarenja otpadom i njihovi odnosi, in Barbić J (ed.) *Pravno uređenje gospodarenja otpadom*, Zagreb, Hrvatska akedmija znanosti i umjetnosti, pp. 75–95

39. TehnoEko (2024) *Kompostane u Hrvatskoj: Zašto su zapele u ekološkim i financijski problemima?*,18 April, https://www.tehnoeko.com.hr/otpad/kompostane-u-hrvatskoj-zasto-su-zapele-u-ekoloskim-i-financijski-problemima/a/10586 [15.06.2025]

40. Turudić M (2018) Inspekcijski nadzor nad gospodarenjem otpadom, Barbić J (ed.) *Pravno uređenje gospodarenja otpadom*, Zagreb, Hrvatska akedmija znanosti i umjetnosti, pp. 157–170.

41. Unikom (2018) *Osijek je prvi grad koji u stambenim zgradama prikuplja biootpad*, 8 May, https://unikom.hr/osijek-je-prvi-grad-koji-u-stambenim-zgradama-prikuplja-biootpad [15.06.2025]

42. Vidović I & Runko Luttenberger L (2019) Doprinos kućnog kompostiranja zaštiti okoliša, *Politehnika: Časopis za tehnički odgoj i obrazovanje* 3(1), pp. 41–50, https://doi.org/10.36978/cte.3.1.4

43. Voća N, Kufrin J, Ribić B, Krička T, Kučar Dragičević S & Požgaj Đ (2014) Gospodarenje i energetska oporaba biorazgradljivog dijela komunalnog otpada u Republici Hrvatskoj, *49. hrvatski i 9. međunarodni simpozij agronoma*, pp. 26–35

44. Zagreb Holding Ltd. (2025) *Godišnji konsolidirani izvještaj Grupe Zagrebački holding za 2024. godinu*, https://www.zgh.hr/investitori/financijska-izvjesca/10887 [21.07.2025]
45. Zero Waste Cities (2020) *The Story of Prelog, the First Croatian City to Prove That, If There is the Will, Change is Possible*, https://zerowastecities.eu/wp-content/uploads/2020/10/2020_10_07_zwe_the_story_of_prelog_hr.pdf [15.06.2025]
46. Zero Waste Europe (2024) *Krk Becomes First Island in Croatia and Second Worldwide to Become Zero Waste Island*, 30 October, https://zerowasteeurope.eu/press-release/krk-becomes-first-island-in-croatia-and-second-worldwide-to-become-zero-waste-island/ [15.06.2025]

EU Legal Sources

1. Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste, OJ L 182, 16.7.1999
2. Council Regulation (EU) 2022/1854 of 6 October 2022 on an emergency intervention to address high energy prices, OJ L 261I, 7.10.2022
3. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, OJ L 312, 22.11.2008

National Legal Sources (in chronological order)

1. Waste Act, OG no. 178/04, 111/06, 60/08 and 87/09
2. Waste Management Strategy, OG no. 130/05
3. Waste Management Plan for the Period 2007–2015, OG no. 85/07
4. Sustainable Waste Management Act, OG no. 94/13, 73/17, 14/19, 98/19
5. Waste Management Plan of the Republic of Croatia for the period 2017–2022, OG no. 3/17
6. Decree on Municipal Waste Management, OG no. 50/17, 84/19, 14/20 and 31/21
7. Waste Management Act, OG no. 84/21 and 142/23
8. Amendment to the Waste Management Plan of the Republic of Croatia for the Period 2007–2015, OG no. 1/22
9. Waste Management Ordinance, OG no. 106/22 and 138/24

10. Food Waste Prevention and Reduction Plan of the Republic of Croatia for the period 2023 to 2028, OG no. 156/22
11. Waste Management Plan of the Republic of Croatia for the Period 2023–2028, OG no. 84/23
12. Decree on the Unit Fee for Waste Disposal, OG no. 137/24

Local Legal Sources

1. Decision on the Method of Providing the Public Service of Municipal Waste Collection in the Area of the City of Koprivnica, Gazette of the City of Koprivnica no. 1/22
2. Decision on the Method of Providing the Public Service of Municipal Waste Collection in the Area of the City of Slatina, Gazette of the City of Slatina, no. 7/23

Table of Cases

Constitutional Court of the Republic of Croatia

1. U-I-2934/2022 of 14 October 2023, OG no. 142/23
2. U-II-2492/2017 et al. of 23 March 2021, OG no. 31/21