

ANIMAL AND VEGETAL WASTE GENERATED BY EU MEMBER STATES IN THE PERIOD 2016 – 2020

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Abstract: Waste generation poses a significant challenge in today's world, prompting ongoing efforts to find effective solutions. While different countries have made varying progress in addressing this issue, environmental protection and the enhancement of food product quality remain key drivers. Notably, the agricultural sector enjoys an advantage: a relatively small proportion of its waste is hazardous. In fact, most of the waste generated is both safe and recyclable. Proper management of processing procedures is crucial to unlock its potential for widespread utilization across diverse economic activities and in various forms. This study aims to track the trends and compare agricultural waste generation in Bulgaria with that of the other EU Member States. It spans the years 2016, 2018, and 2020, analysing waste data by type for each year. Using available Eurostat data, the authors have made their own calculations. The findings underscore the importance of addressing waste management promptly, emphasizing the need to limit and minimize waste generation within the European Union during the specified period.

Keywords: waste; agriculture; innovation

JEL codes: O3; O13; Q16; Q53

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Introduction

Agricultural waste is defined as:

- residues from the cultivation and processing of agricultural raw materials;
- non-productive products from the production and processing of agricultural goods;
- products containing materials with an economic value lower than the costs of their collection, transportation, and processing, but which can be reused (Obi et al., 2016).

The composition of agricultural waste depends on the type of agricultural activities, as they can be in the form of liquids, suspensions, or solid substances (Koul et al., 2022). The main categories of agricultural waste that affect the sustainability of economic activities in the sector include:

- plant waste (leaf residues, seed husks, stems, straw, husks, weeds);
- livestock waste (urine, manure, wash water, residual milk, waste fodder);
- poultry waste (spilled food, feathers, excrement, bedding material);
- slaughterhouse waste (blood, hair, skins, meat, bones, etc.);
- agro-industrial waste (bagasse, molasses, peels [orange, potato, cassava], cellulose, etc.);
- aquaculture waste (uneaten feed, faecal waste) (Seidavi et al., 2019; Tripathi et al., 2019; Duque-Acevedo et al., 2020).

Bioeconomy strategies based on proper management of agricultural waste are a prerequisite for:

- optimizing the use of animal excrements, manure, and urine to ensure food and health security;
- the responsible burning of plant waste to ensure food and health security;
- the use of waste to generate value-added products;
- stability and security for farmers;
- employment prospects for young people in agriculture (Blagoev, 2023);

- sustainability in the agricultural sector (Agamuthu, 2009; Bracco et al., 2018).

Growing agricultural production leads to an increase in the volume of livestock waste, agricultural crop residues, and by-products of agricultural activity. It is generally believed that agricultural waste represents a significant portion of the total volume of waste from all economic activities (Obi et al., 2016). It is necessary to broaden the outlook of society and agricultural producers and to show understanding regarding the hidden benefits (less or no soil, air, and water pollution, better human health, an alternative source of income, etc.) associated with the biological and biotechnological management of agriculture (Westerman & Bicudo, 2005). It is necessary to apply an approach that stimulates the research and development of renewable energy technologies, as well as to invest in and apply green energy (Kotzeva, 2003; Branzova, 2024). Most agricultural waste can be decomposed, and the products obtained from the decomposition process not only provide essential nutrients for plants but make the soil porous (improving aeration and water retention). Positive effects of converting agricultural waste into valuable resources include:

- creating green markets and employment opportunities;
- reducing greenhouse gas pollution;
- lowering dependence on fossil fuels;
- clean, safe, and sustainable agriculture (Mohanty et al., 2002; Scarlat et al., 2015).

Improper treatment of plant waste generates greenhouse gases (carbon dioxide, nitrogen oxide, methane), which can be considered as a potential risk to the environment and the population of any country (Searchinger et al., 2008; Kaab et al., 2019). Fertile soil for growing crops is also a favourable environment for the development of various insects and weeds, which are destroyed by pesticides. Their excessive and improper use is a prerequisite for food poisoning and contaminated agricultural lands due to the chemicals' durability and toxicity (Dien & Vong, 2006).

Animal waste accounts for the largest share of agricultural waste. Livestock farms are usually located close to settlements, and air pollution poses a significant problem. The intensity of odour depends on animal density, ventilation, temperature, and

humidity. The sources of air pollution include:

- odours emanating from cells as a result of animal digestion;
- the rotting process of organic matter in manure;
- animal urine and/or excess feed (Thao, 2003).

With the increase in aquaculture farming, the use of feed to improve production also rises. The amount of feed used in a given system is the most important factor in determining the amount of waste generated. One of the main types generated in aquaculture is metabolic waste, which can be dissolved or suspended. Feeding norms depend on the ambient temperature. An increase in temperature leads to an increase in feeding, which leads to an increase in waste generated (Miller & Semmens, 2011).

Limiting and recycling agricultural waste is necessary to reduce:

- the negative impact of economic growth on the environment;
- people's dependence on resource use;
- pressure on the soil, biodiversity, and global food security (UNEP, 2011).

Waste generated by the EU and Member states in the period 2016 – 2020

Animal and vegetal waste (AVW), as part of agriculture, forestry, and fishing (AFF) waste, is particularly important to analyse because the main type of waste biomass produced in the agricultural sector comes from it. In that sense, the analysis shall concern the animal and vegetal waste generated by the EU and individual member states, including animal and mixed food waste, vegetal wastes, and animal faeces, urine, and manure. Furthermore, the analysis specifically focuses on Bulgaria and the member states that generate the highest amounts of AVW in the EU. In order to follow the most recent development trends, our analysis period covers the latest available annual data in the Eurostat database – for 2016, 2018, and 2020. The data has been analysed using descriptive statistics and visualizations to identify trends and patterns in animal and vegetal waste generation over this period. Tables and figures by type of waste have been drawn up as the authors' own calculations, estimated based on the available Eurostat data.

Table 1. Share of the animal and vegetal waste (AVW) in the total agriculture, forestry, and fishing (AFF) waste generated in 2016, 2018, and 2020 in tons

Country	AFF in 2016 (t)	AVW in 2016 (t)	Share of AVW in the total AFF in 2016 (%)	AFF in 2018 (t)	AVW in 2018 (t)	Share of AVW in the total AFF in 2018 (%)	AFF in 2020 (t)	AVW in 2020 (t)	Share of AVW in the total AFF in 2020 (%)
European Union - 27 countries (from 2020)	20,130,000	17,020,000	84.5	20,160,000	16,630,000	82.5	21,350,000	17,550,000	82.2
Belgium	269,190	139,972	52.0	362,508	177,146	48.9	417,301	142,160	34.1
Bulgaria	617,689	578,000	93.6	308,760	277,069	89.7	892,764	815,772	91.4
Czechia	114,575	28,647	25.0	411,533	121,830	29.6	398,041	113,387	28.5
Denmark	201,648	110,732	54.9	373,978	288,466	77.1	389,498	288,068	73.9
Germany	1,126,134	766,369	68.1	982,106	685,468	69.8	1,004,332	627,724	62.5
Estonia	113,946	79,759	70.0	138,195	94,030	68.0	195,258	152,932	78.3
Ireland	105,033	12,030	11.5	296,865	205,353	69.2	275,414	190,804	69.3
Greece	255,169	234,264	91.8	466,119	396,385	85.0	644,283	574,856	89.2
Spain	6,271,464	5,730,082	91.4	6,258,251	5,718,373	91.4	6,330,651	5,778,781	91.3
France	1,303,642	775,466	59.5	1,309,912	764,998	58.4	1,291,230	750,421	58.1
Croatia	496,153	486,305	98.0	550,471	539,304	97.9	565,300	556,013	98.4
Italy	320,928	78,487	24.5	332,554	70,438	21.2	348,501	47,806	13.7
Cyprus	19,453	9,336	48.0	19,783	10,501	53.1	21,156	11,185	52.9
Latvia	144,075	23,284	16.2	132,746	90,406	68.1	133,282	45,647	34.3
Lithuania	280,625	246,958	88.0	293,676	251,950	85.8	301,722	259,468	86.0
Luxembourg	30,890	29,401	95.2	8,330	3,950	47.4	11,445	6,527	57.0
Hungary	484,320	450,723	93.1	449,607	397,228	88.4	295,281	272,387	92.3
Malta	10,565	10,034	95.0	12,292	11,385	92.6	11,851	11,251	94.9
Netherlands	5,085,249	4,647,019	91.4	4,678,699	4,186,120	89.5	4,896,548	4,412,207	90.1
Austria	129,834	59,072	45.5	139,870	61,174	43.7	168,233	94,651	56.3
Poland	534,931	467,314	87.4	431,500	308,465	71.5	281,119	98,121	34.9
Portugal	55,520	20,359	36.7	62,073	10,613	17.1	94,347	41,317	43.8
Romania	507,712	482,285	95.0	584,619	559,509	95.7	720,130	699,920	97.2
Slovenia	63,248	52,466	82.9	61,665	52,735	85.5	55,730	123	0.2
Slovakia	788,559	748,060	94.9	529,786	446,383	84.3	562,354	515,613	91.7
Finland	0	0	0.0	0	0	0.0	0	0	0.0
Sweden	804,382	745,977	92.7	962,141	902,526	93.8	1,045,928	995,375	95.2
Average for the EU 27	745,738	630,089	66.7	746,594	615,993	67.5	790,804	648,241	63.5

Source: Authors' own calculations based on Eurostat data.

The overall trends based on the data presented in Table 1 suggest a slight increase in the total amount of AFF waste – it has increased in the EU over the years from 20.13 million tons in 2016 to 21.35 million tons in 2020. Some countries experienced significant cumulative increases in AFF waste over this period, such as Belgium (+55%) and Bulgaria (+45%). Conversely, other countries have seen cumulative decreases in AFF waste, such as Hungary (-43%) and Portugal (-90%).

The AVW in the total AFF waste across the entire EU remained relatively stable, ranging from 82.2% to 84.6% over the examined period. However, it significantly varied across countries, ranging from 11.45% in Ireland in 2016 to 98.36% in Croatia in 2020. Spain, the Netherlands, and France had the highest total amounts of AFF waste cumulatively for the entire period, while smaller countries like Luxembourg and Malta had relatively lower amounts.

The average EU country saw a slight increase in AFF waste over these years, from 745.74 million tons in 2016 to 790.80 million tons in 2020. The average share of AVW in total AFF waste remained relatively stable, ranging from 63.53% to 66.74% throughout the period. It should be noted that Finland is not included in the table, as no available data were present, while Slovenia had an extremely low percentage of AVW in total AFF waste.

Overall, the data suggests that the EU is generating stable amounts of agricultural, forestry, and fisheries waste, with a significant portion of this waste being animal and vegetal waste. From this perspective, the analysis shall continue by further decomposing and examining the AFF waste category, specifically focusing on the animal and vegetal waste subcategories.

Figure 1 presents data on the composition of AVW by subcategories and their share in the total AFF waste generated by each member state in 2016. Animal and vegetal waste consists of three subcategories: animal and mixed food waste; vegetal waste; and waste from animal faeces, urine, and manure.

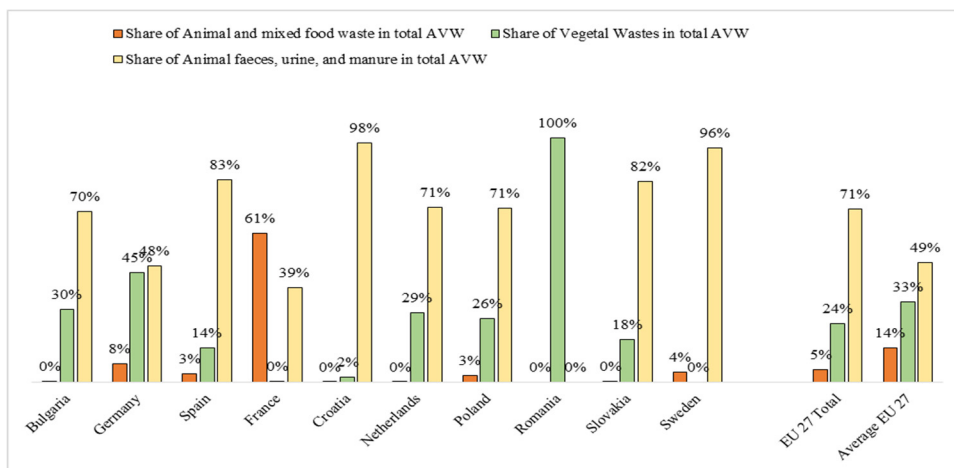
In 2016, the share of waste from animal faeces, urine, and manure in the total animal and vegetal waste generated across the entire EU was 71%, with a 49% average share among member states. Vegetal waste had a 24% share of EU-wide total AVW, with a 33% average share for member states, while the share of animal and mixed food waste was just 5%, and member states averaged a 14% share.

The member state that had the highest share of animal and mixed food waste in its AVW for 2016 was France (61%).

Romania, on the other hand, was the member state with the highest share of vegetal waste in 2016 – 100%, without generating any other types of waste at all. Other countries having a significant share of vegetal waste in their total AVW generation

included Germany (45%), Bulgaria (30%), and the Netherlands (29%). These values were significant compared to other member states that also generated high amounts of AVW.

The member states with the highest generated share of waste from animal faeces, urine, and manure in their total AVW were Croatia (98%) and Sweden (96%). Other countries reporting a significant share of waste from animal faeces, urine, and manure in the waste generated in 2016 included Spain (83%) and Slovenia (82%). As for Bulgaria, the share of the waste from animal faeces, urine, and manure in the country’s total AVW generated in 2016 was 70%, which was 21% more than the EU average.



Source: Authors’ own calculations based on Eurostat data.

Figure 1. Composition of animal and vegetal waste (AVW), by subcategory and share of the total, for the EU member states with the highest AVW generated in 2016

Figure 2 presents data on the composition of animal and vegetal waste (AVW) by subcategories and their share in the total AVW generated by each member state in 2018.

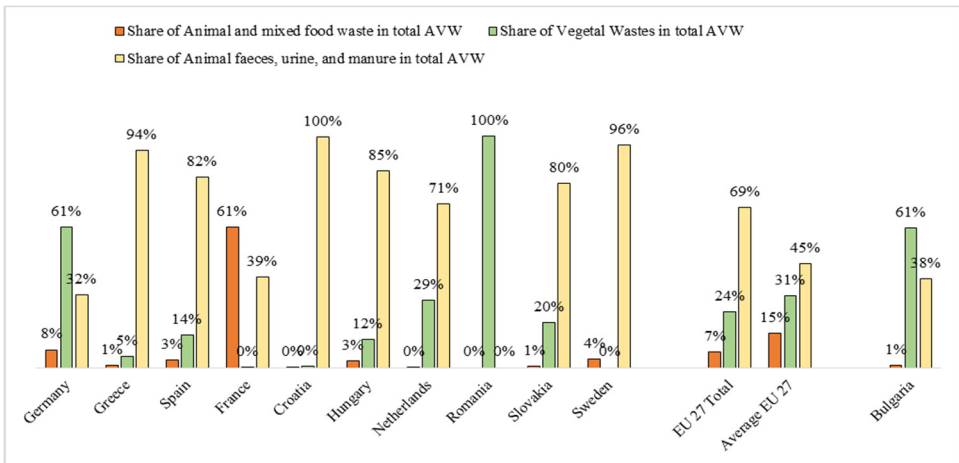
In 2018, the share of waste from animal faeces, urine, and manure in the total animal and vegetal waste generated in the entire EU was 69%, with a 45% average share for member states. Vegetal waste represented a 24% share in the EU AVW, with a 31% average share for member states, while the share of animal and mixed food was just 7%, with an average of 15% among member states.

The member state that had the highest share of animal and mixed food waste in its AVW for 2018 was France (61%). As for Bulgaria, the share of animal and mixed food waste in the country’s total AVW generated was just 1%, far below the

EU average level.

As in 2016, Romania was the member state with the highest share of vegetal waste in 2018 – 100%, with no other types of waste generated at all. Other countries with a significant share of vegetal waste in their total AVW generation for 2018 included Germany (61%), Bulgaria (61%), and the Netherlands (29%). These values were significant compared to the other member states that also generated significant amounts of AVW.

The member state with the highest share of waste from animal faeces, urine, and manure in its total generated AVW in 2018 was Croatia (100%) – the country generated no waste from the other two subcategories at all. Other countries reporting a significant share of waste from animal faeces, urine, and manure in their generated AVW for 2018 included Sweden (96%) and Greece (94%). Bulgaria’s share of waste from animal faeces, urine, and manure as part of the country’s total AVW generated in 2018 was 38%, which was 7% below the EU average level.



Source: Authors’ own calculations based on Eurostat data.

Figure 2. Composition of animal and vegetal waste (AVW), by subcategory and share of the total, for the EU member states with the highest AVW generated in 2018

Figure 3 presents data on the composition of AVW by subcategories and their share in the total AVW generated by each member state in 2020. The animal and vegetal waste consist of three subcategories, namely animal and mixed food waste, vegetal waste and waste from animal faeces, urine and manure.

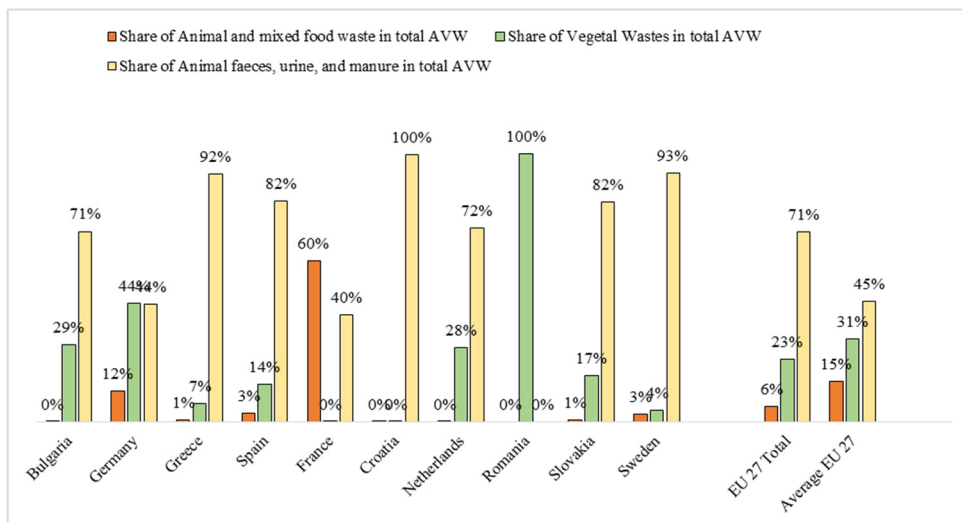
In 2020, the EU share of waste from animal faeces, urine, and manure in the total animal and vegetal waste generated in the entire EU was 71%, with a 45% average

share for member states. Vegetal waste represented a 23% share of the total generated AVW across the EU, with a 31% average share for member states, while the share of animal and mixed food was just 6%, and the average of share among member states was 15% .

Again, in 2020, the member state that had the highest share of animal and mixed food waste in its AVW was France (60%).

Once again, as in 2016 and 2018, it was Romania being the member state with the highest share of vegetal waste in 2020 – 100 %, with the country no generating other types of waste at all. Other countries having a significant share of vegetal waste in their total AVW generation included Germany (44%), Bulgaria (29%) and the Netherlands (28%). These values were significant compared to those of other member states that also generate high amount of AVW.

The member state where the share of waste from animal faeces, urine and manure in its total AVW generated was the highest in 2020 again was Croatia (100%) as the country not generating waste from the other two subcategories at all. Other countries reporting a significant share of waste from animal faeces, urine and manure in the AVW generated in 2020 included Sweden (93%) and Greece (92%). As regards to Bulgaria, the share of the waste from animal faeces, urine and manure in the country’s total AVW generated in 2020 was 71% which was 26% higher than the EU average level.

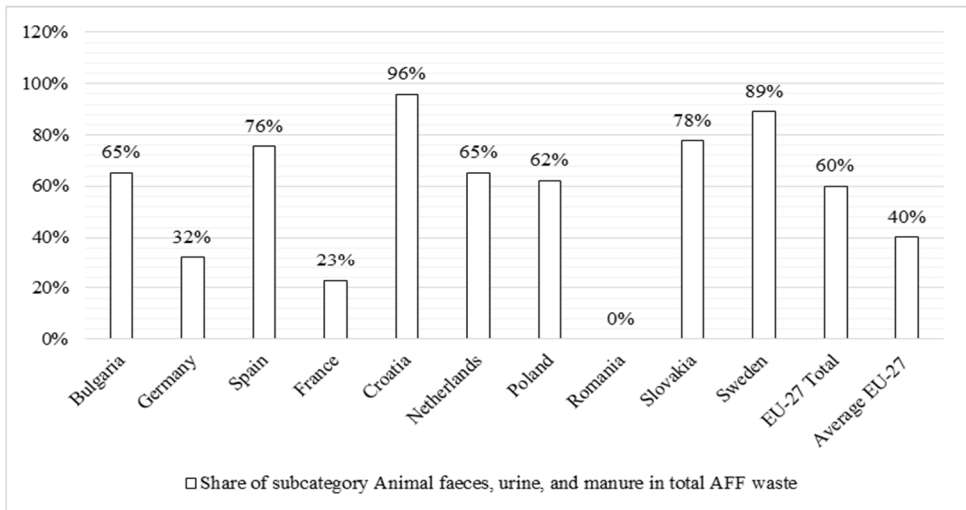


Source: Authors’ own calculations based on Eurostat data.

Figure 3. Composition of animal and vegetal waste (AVW), by subcategory and share of the total, for the EU member states with the highest AVW generated in 2020

Figure 4 presents data on the share of waste from animal faeces, urine, and manure in the total AFF waste generated by the EU member states where the most AFF waste was generated in 2016. In 2016, the share of waste from animal faeces, urine, and manure in the total EU AFF waste generated was 60%; the average share among member states was 40%.

The member states that had the highest share of waste from animal faeces, urine, and manure in their total AFF waste generated in 2016 were Croatia (96%) and Sweden (89%). Other countries registering high shares of waste from animal faeces, urine, and manure in their total AFF waste generated included Slovakia (78%) and Spain (76%). The Bulgarian share of waste from animal faeces, urine, and manure in the country's total AFF waste generated in 2016 was equal to those of the Netherlands and Poland, representing 65%, which was 25% higher than the EU average level. The member state that had the lowest share of waste from animal faeces, urine, and manure in its total AFF waste generated in 2016 was France (23%), while Romania did not generate any such waste at all.



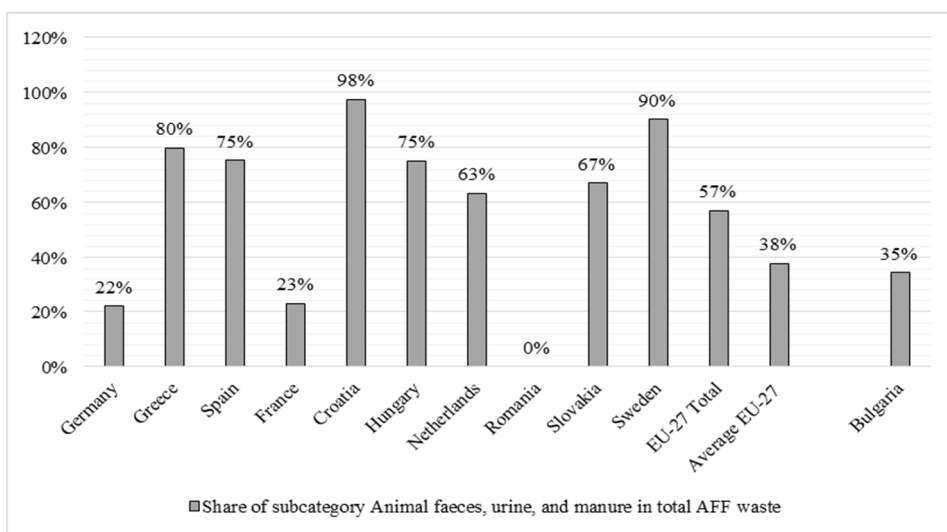
Source: Authors' own calculations based on Eurostat data.

Figure 4. Composition of animal and vegetal waste (AVW), by subcategory and share of the total, for the EU member states with the highest AVW generated in 2016

Figure 5 presents data on the share of waste from animal faeces, urine, and manure in the total AFF waste generated by the EU member states which generated the highest AFF waste amounts in 2018. In that year, the share of waste from animal

faeces, urine, and manure in the EU-wide total AFF waste generated was 57%, with a 38% average share among member states.

The member states that had the highest share of waste from animal faeces, urine, and manure in their total AFF waste generated in 2018 were Croatia (98%) and Sweden (90%). Other countries registering high shares of waste from animal faeces, urine, and manure in their total AFF waste generated included Hungary (75%) and Spain (75%). As regards to Bulgaria, the share of the waste from animal faeces, urine and manure in the country’s total AFF waste generated in 2018 was 35% which was 3% below the EU average value. The member state that had the lowest share of waste from animal faeces, urine and manure in its total AFF waste generated in 2018 again was France (23%) with Romania not generating such waste at all.



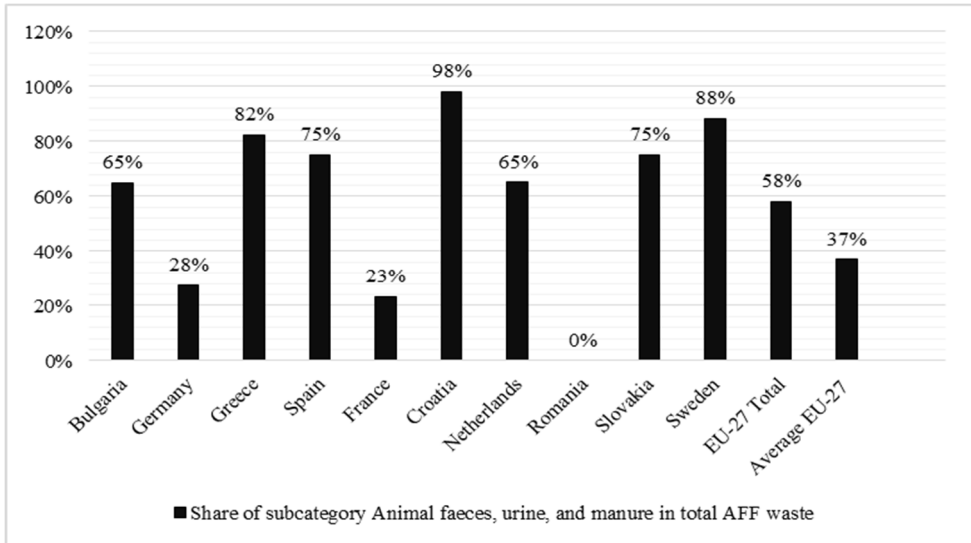
Source: Own calculations based on Eurostat data.

Figure 5. Composition of animal and vegetal waste (AVW), by subcategory and share of the total, for the EU member states with the highest AVW generated in 2018

Figure 6 presents data on share of waste from animal faeces, urine, and manure in the total AFF waste generated by the EU member states which generated the highest AFF waste amounts in 2020. In 2020, the share of waste from animal faeces, urine, and manure in the total generated AFF waste was 58% for the entire EU, with an average share of 27% among EU member states.

The member states that had the highest share of waste from animal faeces, urine, and manure in their total AFF waste generated in 2020 were again Croatia (98%) and Sweden (88%). Other countries registering high shares of waste from animal faeces,

urine, and manure in their total AFF waste included Slovakia (75%), Spain (75%), and Greece (82%). In Bulgaria, the share of the waste from animal faeces, urine, and manure out of the country's total AFF waste generated in 2020 was equal to that of the Netherlands, representing 65%, which was 28% higher than the EU average. The member state that had the lowest share of waste from animal faeces, urine, and manure in its total AFF waste for 2020 was France (23%); Romania once more did not generate such waste at all.



Source: Own calculations based on Eurostat data.

Figure 6. Composition of animal and vegetal waste (AVW), by subcategory and share of the total, for the EU member states with the highest AVW generated in 2020

Conclusion

Waste generation stands as a critical challenge in the modern world, with ongoing efforts to find effective solutions. The results of our EU waste analysis during the specified period underscore the importance of this issue and emphasize the urgency of timely limitation and minimization of waste production.

Overall, this analysis of agricultural waste in Bulgaria has revealed that the country has a significant share of animal and vegetal waste (AVW) in its total agriculture, forestry, and fishing (AFF) waste generated. In 2016, Bulgaria produced 617,689 tons of AFF waste, with AVW accounting for 578,000 tons, or 93.57% of the total. The share of AVW in total AFF waste has remained relatively stable over the years, ranging from a slight decrease at 89.74% in 2018 to a slight increase at 91.38% in 2020.

In terms of the composition of AVW, the share of waste from animal faeces, urine, and manure in Bulgaria's total AVW generated in 2016 was 70%. That was 21% more than the EU average, placing Bulgaria among the countries reporting a significant share of vegetal waste in their total AVW – 30% or higher. Conversely, the share of animal and mixed food waste in the country's total AVW was negligibly low at less than 1%.

In 2018, Bulgaria remained among the member states with the lowest share of animal and mixed food waste in the total AVW generated in the country; Bulgaria's 1% share was far below the EU average level. On the other hand, the share of vegetal waste more than doubled since 2016, accounting for a 61% share. This was also at the expense of waste from animal faeces, urine, and manure, which registered a nearly double decrease, with a more than 32% share – 7% below the EU average level.

Last, but not least, the 2020 share of waste from animal faeces, urine, and manure in Bulgaria's total generated AVW regained its 2016 level, accounting again for around 70% (71%), which was 26% higher than the EU average level. Respectively, the share of vegetal waste in 2020 accounted for 29%, while the share of animal and mixed food waste in the country's total AVW was negligibly low and near 0%.

As the waste from animal faeces, urine, and manure in Bulgaria's total AVW in 2016 and 2020 represented the highest value, it may be further examined in terms of the total AFF waste generated. In that sense, it is worth noting that the share of waste from animal faeces, urine, and manure in Bulgaria's total AFF waste in 2016 was equal to those of the Netherlands and Poland, representing 65%, which was 25% higher than the EU average level. As for 2018, the share of waste from animal faeces, urine, and manure in Bulgaria's total AFF waste fell to 35% (3% below the EU average value), following the trend of an increased share of vegetal waste. Conversely, in 2020, the share of waste from animal faeces, urine, and manure in Bulgaria's total AFF waste generated regained an upward trend, equalling that of the Netherlands and representing 65%, which was 28% higher than the EU average.

Ultimately, Bulgaria's AVW composition has significant implications for waste management and environmental protection. Poorly managed vegetal waste can lead to decomposition, releasing greenhouse gases. Nutrient-rich runoff from vegetal waste can impact water quality and aquatic ecosystems, while the proper management (e.g., composting) improves soil fertility by enriching it with nutrients from vegetal waste.

On the other hand, manure serves as a valuable source of nutrients, reduces the need for external fertilizers, and contributes to sustainable crop production and soil quality. Very high percentages of the nitrogen, phosphorus, and potassium found in animal feeds are excreted in manure. These nutrients can replace the need for purchased fertilizers, benefiting crop growth and soil health.

Agriculture, being a high-risk sector, grapples with inherent challenges – some of which lie beyond our direct control. In Bulgaria, the management of production waste within agriculture is a relatively recent concern, yet it harbours significant growth potential. To stabilize the sector and enhance its long-term sustainability, an effective waste management strategy must be put into action. This strategy should be tailored to the unique intricacies of agriculture, recognizing its multifaceted nature and addressing the wide-ranging consequences. The State’s involvement plays a pivotal role. By supporting waste management initiatives, the government can facilitate the seamless implementation of diverse tools aimed at bolstering environmental protection through the recycling of agricultural waste products. Embracing innovative practices in farm waste management represents a fresh approach for Bulgarian agriculture – one that holds substantial promise for further development in this crucial domain.

Conflicts of interest

The authors have no conflicts of interest to declare.

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