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# DEVELOPMENT TRENDS AND INNOVATIVE APPROACHES IN AGRICULTURAL WASTE MANAGEMENT IN BULGARIA AND THE EUROPEAN UNION[3]

*The reduction and effective use of waste generated by various economic activities has become a global issue that goes beyond individual countries. Agriculture as an integral part of the economy also contributes to environmental pollution, although the waste from various agricultural activities is mostly safe and recyclable. That quality enables agricultural waste reintegration into the economy (through appropriate processing) and provides opportunities for utilizing its full potential. In that sense, the aim of the study is to analyse the waste trends for the period 2016 – 2020, to compare the waste generated by agriculture in Bulgaria with one of the other member states of the European Union as well as to present good examples of its innovative use.*
*Keywords: waste; agriculture; innovation*
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## 1. Introduction

The reduction and effective use of waste from various economic activities is a priority of modern economies. Ways are being sought to reduce the amount of generated waste through non-invasive methods that serve as an alternative to conventional practices. Although the progress of the countries in that field varies, protecting the environment and human health remains a universal trend. As the global population and industrial capacities of the economies continue to expand, the generation of waste has significantly increased. In order to mitigate the discharge of waste into the environment and avoid ecological catastrophe, it is highly important to implement effective solutions in this regard. One feasible approach to achieve this goal is the re-use of agricultural waste.

The main advantage of the agricultural sector is that a very small share of its waste is hazardous. In their main part, the residual products generated are safe and recyclable, and this is a prerequisite for their wide application in various economic activities and in various

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forms. This study aims at observing the waste trends in the period 2016 – 2020, comparing the agricultural waste generated in Bulgaria and other EU member states as well as highlighting good examples of waste innovative use.

According to the Waste Management Act (SG, No. 86 of 30.09.2003), waste is defined as "any substance, object or part of an object which the holder discards or intends or is required to discard and which belongs to at least one of the categories listed in the Waste Management Act." At its core, waste is a combination of losses and residues. Agricultural wastes are biodegradable items that can occur at different stages of the product life cycle (Zhivkova, 2018).

Due to the diversity of cultivated plants and animals, agricultural waste is very diverse in nature. They can be sediments from washing and cleaning; animal and plant tissue waste; waste plastics; animal faeces, urine and manure; wastewater; agrochemical waste; metal waste; materials unfit for consumption or processing; waste from solvent extraction; waste from preservatives, etc.

There are significant opportunities to develop the use of agricultural residues and by-products, as well as waste. Heterogeneous forms of biomass can be used for energy purposes: wood and wood waste, energy-rich crops, agricultural waste, straw, corn stalks, livestock liquid waste, etc., and sewage sludge (Popov, 2020). Waste biomass from agriculture is a partial substitute for non-renewable energy sources as it not only can be converted into biofuel, but it can also be used for food (Beluhova–Uzunova, Shishkova, Ivanova, 2023). The utilization of sludge in terms of agriculture is a prerequisite for maintaining ecological sustainability and soil fertility (Bashev, Ivanov, 2021).

Organic waste management is closely connected to the reformulation and transformation of biological resources (from agriculture) into new products (Branzova, Nestorov, 2023), (Bottausci et al., 2022). Modern animal husbandry has a need and, at the same time, provides an opportunity for organic fertilizers to not be considered as unnecessary waste, but as a valuable resource (Apostolov, Krasteva, 2008). The effective use of organic fertilizers from and in poultry farms or in crop production has a positive effect, both for the farms themselves and for environmental protection (Draganova, Milkov, 2010).

According to Atanasov (2023), it is necessary to consider the agricultural waste issue from the modern concepts of circular bioeconomy perspective. The main part of the agricultural by-products is biomass that cannot be used in its primary state, but through appropriate treatment, it is quite possible to reintegrate it into the production process and thus absorb its full value.

Moreover, according to the author, the least favourable but also good solution is that biomass is composted and used in the production of biogas and soil improvers or included in the composition of coal and pellets for more environmentally friendly heating of farm buildings or households. "The exerted by the agricultural activities anthropogenic stress on ecosystems must be minimized as strategies to increase the resilience of these ecosystems must be adopted so that they can cope with it more easily" (Atanasov, 2023).

## 2. Comparative and trend analysis related to waste generated by the EU and Member states in the period 2016 – 2020

The study examines the most up-to-date data from the European Union's Eurostat database. The data was analyzed using descriptive statistics to identify trends and patterns in agricultural waste generation over a defined period in Bulgaria and in the EU. The analysis shall concern the total waste generated in the EU by all economic activities (TW); waste generated by agriculture, forestry and fishery (AFF) in the EU and in individual member states and animal and vegetal waste (AVW) generated by the EU and the member states, including animal and mixed food waste, vegetal wastes and animal faeces, urine and manure. The analysis period covers the years of 2016, 2018 and 2020 as the most up-to-date and latest data published. Tables by type of waste have been drawn up for each year. Own calculations based on the available Eurostat data were estimated.

Table 1 presents data on the total waste generated in the EU member states by all economic activities in 2016 in tons. They amounted to more than 2.2B tons generated in total, with an average amount of more than 83.6M tons per member state.

Germany and France were the member states that generated the highest amount of waste by all economic activities. Countries like Poland, Romania and Italy also reported high amounts of waste generated by all economic activities. Bulgaria also generated a significant amount of waste by all economic activities and ranked 10th in the EU with 36.8M tons more than the EU average for 2016.

On the other hand, Latvia and Malta were the member states that generated the lowest amount of total waste by all economic activities in 2016 with Cyprus also reported a low value of the observed indicator.

When relating the total waste generated by all economic activities (TW) of the EU member states with the waste generated by agriculture, forestry and fisheries (AFF) of those countries, it is noticeable that the latter represented a very small share. In that sense, Croatia was the member state that registered the highest share of AFF from the country`s TW with 9.24%, while Latvia and Slovakia`s AFF share of their TW comprised for around 7%.

The share of Bulgaria`s AFF waste generated in the country`s total waste generated by all economic activities was 0.51%, which was twice below the EU average – 1.82%. For countries like Italy, Austria, Germany, Poland and Romania, the AFF waste represented an insignificant share of the countries` TW, comprising of just 0.21%, 0.28%, 0.29% and 0.29% respectively.

Spain and the Netherlands were the countries with the highest percentage of total AFF waste generated in the EU in 2016, with an average of 3.70% for the EU member states. The lowest percentage, below the EU average, was registered in Slovenia, Portugal and Bulgaria on the other hand remained around the EU average level with a share of 3.07% of the total AFF waste generated in the EU.

The EU total AFF waste measured in kilogram per hectare of utilized agricultural area (kg/h UAA) in 2016 was 128.5 kg/h with an EU average of 251.1kg/h per member state, while the Netherlands registered the highest value of the observed indicator. Other countries registering

significant amounts of AFF waste per kg/h UAA included Malta, Slovakia and Croatia. For Bulgaria, the AFF waste per kg/h UAA in 2016 was 137.5 kg/h., which is around half of the average for the EU member states.

AFF waste measured in kilogram per capita for the entire EU in 2016 was 45 kg., with an EU average of 56 kg per member state, as the Netherlands and Slovakia were the countries that generated the most AFF waste per capita. Croatia and Spain on the other hand reported 119 kg and 135 kg of AFF waste per capita in 2016.

Bulgaria also generated a significant amount of AFF waste per capita, as the country ranked 6th among all EU member states in 2016 and above the EU average level by 31 kg.

The lowest levels of AFF waste per capita in 2016 were reported in Portugal and Italy with the Czech Republic also registering low values of the indicator. Other countries with low levels of AFF waste per capita included Austria, Germany and Poland.

***Table 1. Total waste generated by all economic activities of EU Member States in 2016***

| Country | Total Waste Generated (t) | AFF Waste (t) | Share of the total (%) | % of AFF, EU27 = 100 % | KG PER CAPITA AFF | UAA | KG/UAA |
|---|---|---|---|---|---|---|---|
| EU 27 (2020) | 2,258,910,000 | 20,130,000 | 0.89 | 100 | 45 | 156,658,540 | 128.5 |
| Belgium | 63,152,384 | 269,190 | 0.43 | 1.3 | 24 | 1,354,250 | 198.8 |
| Bulgaria | 120,508,475 | 617,689 | 0.51 | 3.1 | 87 | 4,491,860 | 137.5 |
| Czechia | 25,381,426 | 114,575 | 0.45 | 0.6 | 11 | 3,455,410 | 33.2 |
| Denmark | 20,981,931 | 201,648 | 0.96 | 1 | 35 | 2,614,600 | 77.1 |
| Germany | 400,071,672 | 1,126,134 | 0.28 | 5.6 | 14 | 16,715,320 | 67.4 |
| Estonia | 24,277,879 | 113,946 | 0.47 | 0.6 | 87 | 995,100 | 114.5 |
| Ireland | 15,251,689 | 105,033 | 0.69 | 0.5 | 22 | 4,883,640 | 21.5 |
| Greece | 72,332,353 | 255,169 | 0.35 | 1.3 | 24 | 4,553,830 | 56.0 |
| Spain | 128,958,523 | 6,271,464 | 4.86 | 31.2 | 135 | 23,229,750 | 270.0 |
| France | 322,685,297 | 1,303,642 | 0.40 | 6.5 | 20 | 27,814,160 | 46.9 |
| Croatia | 5,366,953 | 496,153 | 9.24 | 2.5 | 119 | 1,562,980 | 317.4 |
| Italy | 163,827,838 | 320,928 | 0.20 | 1.6 | 5 | 12,598,160 | 25.5 |
| Cyprus | 2,467,042 | 19,453 | 0.79 | 0.1 | 23 | 111,930 | 173.8 |
| Latvia | 1,909,631 | 144,075 | 7.54 | 0.7 | 74 | 1,930,880 | 74.6 |
| Lithuania | 6,674,238 | 280,625 | 4.20 | 1.4 | 98 | 2,924,600 | 96.0 |
| Luxembourg | 10,020,519 | 30,890 | 0.31 | 0.2 | 53 | 130,650 | 236.4 |
| Hungary | 15,938,077 | 484,320 | 3.04 | 2.4 | 49 | 4,670,560 | 103.7 |
| Malta | 1,951,928 | 10,565 | 0.54 | 0.1 | 23 | 11,180 | 945.0 |
| Netherlands | 141,024,020 | 5,085,249 | 3.61 | 25.3 | 299 | 1,796,260 | 2831.0 |
| Austria | 61,225,037 | 129,834 | 0.21 | 0.6 | 15 | 2,669,750 | 48.6 |
| Poland | 182,005,677 | 534,931 | 0.29 | 2.7 | 14 | 14,405,650 | 37.1 |
| Portugal | 14,739,135 | 55,520 | 0.38 | 0.3 | 5 | 3,641,690 | 15.2 |
| Romania | 177,562,905 | 507,712 | 0.29 | 2.5 | 26 | 12,502,540 | 40.6 |
| Slovenia | 5,494,362 | 63,248 | 1.15 | 0.3 | 31 | 488,400 | 129.5 |
| Slovakia | 10,606,966 | 788,559 | 7.43 | 3.9 | 145 | 1,889,820 | 417.3 |
| Finland | 122,869,183 | 0 | 0 | 0 | 0 | 2,194,210 | 0.0 |
| Sweden | 141,625,718 | 804,382 | 0.57 | 4 | 81 | 3,021,350 | 266.2 |
| Avarage EU 27 | 83,663,365 | 745,738 | 1.82 | 3.7 | 56 | 5,802,168 | 251.1 |

*Source: Own calculations based on Eurostat data*

Table 2 presents data on the total waste generated in the EU member states by all economic activities in 2018 in tons. They amounted to more than 2.3B tons generated in total, with an average of 86.6M tons per country.

Germany and France were the member states that generated the highest amount of waste by all economic activities in total. Countries like Poland, Romania and Italy also reported high amounts of waste generated by all economic activities. Bulgaria also generated a significant amount of waste by all economic activities and ranked 9th in the EU with 43.1M tons above the EU average level in 2018.

On the other hand, Latvia was the member state that generated the smallest quantity of total waste by all economic activities in 2018 with Cyprus and Malta also reporting low values of the observed indicator.

When relating the total waste generated by all economic activities (TW) of the EU member states with the waste generated by agriculture, forestry and fisheries (AFF) of those countries, it is noticeable that the latter represents a very small share. In that sense, Croatia was the member state that registered the highest share of AFF in the country`s TW with 9.93%, while Latvia`s AFF share in TW comprised for 7.48%. Bulgaria`s AFF waste share in the country`s total waste generated by all economic activities was 0.24%, which was below the EU average of 1.79%. For countries like Italy and Luxembourg, the AFF waste represented an insignificant share of the countries` TW, comprising of just 0.19% and 0.09% respectively.

In 2018, Spain and the Netherlands remained the countries with the highest percentage of the total AFF waste generated in the EU, with an average of 3.70% for the EU member states. Bulgaria also remained below the EU average level with a share of just 1.53% in the total AFF waste generated in the EU.

The EU total AFF waste measured in kilogram per hectare of utilized agricultural area (kg/h UAA) in 2018 was 128.7 kg/h and an EU average was 249.5kg/h, with the Netherlands and Malta registering the highest values of the observed indicator. Other countries registering significant amounts of AFF waste per kg/h UAA included Sweden and Croatia. For Bulgaria, the AFF waste per kg/h UAA for 2018 was 68.7 kg/h., which was far below the EU member states average.

AFF waste measured in kilogram per capita for the EU as a whole in 2018 was 45 kg., with an EU average of 57 kg per member state, as the Netherlands remained the country that generated the most AFF waste per capita. Croatia and Spain on the other hand reported almost equal amounts of AFF waste per capita in 2018. Bulgaria, on the other hand, generated significantly less amount of AFF waste per capita – only 44 kg, which ranked it below the EU average.

The lowest levels of AFF waste per capita in 2018 were reported in Portugal and Italy with Poland also registering low values of the studied indicator.

***Table 2. Total waste generated by all economic activities of EU Member States in 2018***

| Country | Total Waste Generated (t) | AFF Waste (t) | Share of the total (%) | % of AFF, EU27 = 100 % | KG PER CAPITA AFF | UAA | KG/UAA |
|---|---|---|---|---|---|---|---|
| EU 27 (2020) | 2,338,230,000 | 20,160,000 | 0.86 | 100 | 45 | 156,658,540 | 128.7 |
| Belgium | 68,187,479 | 362,508 | 0.53 | 1.8 | 32 | 1,354,250 | 267.7 |
| Bulgaria | 129,751,823 | 308,760 | 0.24 | 1.5 | 44 | 4,491,860 | 68.7 |
| Czechia | 37,847,614 | 411,533 | 1.09 | 2 | 39 | 3,455,410 | 119.1 |
| Denmark | 21,445,206 | 373,978 | 1.74 | 1.9 | 65 | 2,614,600 | 143.0 |
| Germany | 405,523,624 | 982,106 | 0.24 | 4.9 | 12 | 16,715,320 | 58.8 |
| Estonia | 23,185,581 | 138,195 | 0.60 | 0.7 | 105 | 995,100 | 138.9 |
| Ireland | 13,986,757 | 296,865 | 2.12 | 1.5 | 61 | 4,883,640 | 60.8 |
| Greece | 45,240,333 | 466,119 | 1.03 | 2.3 | 43 | 4,553,830 | 102.4 |
| Spain | 137,822,935 | 6,258,251 | 4.54 | 31 | 134 | 23,229,750 | 269.4 |
| France | 343,307,326 | 1,309,912 | 0.38 | 6.5 | 20 | 27,814,160 | 47.1 |
| Croatia | 5,543,310 | 550,471 | 9.93 | 2.7 | 135 | 1,562,980 | 352.2 |
| Italy | 172,502,773 | 332,554 | 0.19 | 1.7 | 6 | 12,598,160 | 26.4 |
| Cyprus | 2,302,144 | 19,783 | 0.86 | 0.1 | 23 | 111,930 | 176.7 |
| Latvia | 1,773,726 | 132,746 | 7.48 | 0.7 | 69 | 1,930,880 | 68.7 |
| Lithuania | 7,080,538 | 293,676 | 4.15 | 1.5 | 105 | 2,924,600 | 100.4 |
| Luxembourg | 9,014,397 | 8,330 | 0.09 | 0 | 14 | 130,650 | 63.8 |
| Hungary | 18,369,585 | 449,607 | 2.45 | 2.2 | 46 | 4,670,560 | 96.3 |
| Malta | 2,507,070 | 12,292 | 0.49 | 0.1 | 25 | 11,180 | 1099.5 |
| Netherlands | 145,245,469 | 4,678,699 | 3.22 | 23.2 | 272 | 1,796,260 | 2604.7 |
| Austria | 65,666,128 | 139,870 | 0.21 | 0.7 | 16 | 2,669,750 | 52.4 |
| Poland | 175,473,691 | 431,500 | 0.25 | 2.1 | 11 | 14,405,650 | 30.0 |
| Portugal | 15,894,873 | 62,073 | 0.39 | 0.3 | 6 | 3,641,690 | 17.0 |
| Romania | 203,017,193 | 584,619 | 0.29 | 2.9 | 30 | 12,502,540 | 46.8 |
| Slovenia | 8,220,679 | 61,665 | 0.75 | 0.3 | 30 | 488,400 | 126.3 |
| Slovakia | 12,401,870 | 529,786 | 4.27 | 2.6 | 97 | 1,889,820 | 280.3 |
| Finland | 128,251,735 | 0 | 0 | 0 | 0 | 2,194,210 | 0.0 |
| Sweden | 138,667,585 | 962,141 | 0.69 | 4.8 | 95 | 3,021,350 | 318.4 |
| Avarage EU 27 | 86,601,165 | 746,594 | 1.79 | 3.7 | 57 | 5,802,168 | 249.5 |

*Source: Own calculations based on Eurostat data*

Table 3 represents data on the total waste generated in the EU member states by all economic activities for 2020 in tons. They amounted to more than 2.1B tons generated in total, with an average of 79.7M tons per country.

As in 2016 and 2018, Germany and France again were the member states that generated the highest amount of waste by all economic activities in total in 2020. Bulgaria also generated a significant amount of waste by all economic activities and ranked 8th in the EU with 36.6M tons above the EU average in 2020.

On the other hand, Latvia and Cyprus were the member states that generated the smallest quantity of total waste by all economic activities in 2020 with Malta also reported a low value of the observed indicator.

***Table 3. Total waste generated by all economic activities of EU Member States in 2020***

| Country | Total Waste Generated (t) | AFF Waste (t) | Share of the total (%) | % of AFF, EU27 = 100 % | KG PER CAPITA AFF | UAA | KG/UAA |
|---|---|---|---|---|---|---|---|
| EU 27 (2020) | 2,153,950,000 | 21,350,000 | 0.99 | 100 | 48 | 157,414,160 | 135.6 |
| Belgium | 68,061,590 | 417,301 | 0.61 | 2 | 36 | 1,368,120 | 305.0 |
| Bulgaria | 116,387,350 | 892,764 | 0.77 | 4.2 | 129 | 4,564,150 | 195.6 |
| Czechia | 38,486,186 | 398,041 | 1.03 | 1.9 | 37 | 3,492,570 | 114.0 |
| Denmark | 20,135,564 | 389,498 | 1.93 | 1.8 | 67 | 2,629,930 | 148.1 |
| Germany | 401,156,266 | 1,004,332 | 0.25 | 4.7 | 12 | 16,595,020 | 60.5 |
| Estonia | 16,170,358 | 195,258 | 1.21 | 0.9 | 147 | 975,320 | 200.2 |
| Ireland | 16,192,033 | 275,414 | 1.70 | 1.3 | 55 | 4,920,270 | 56.0 |
| Greece | 28,358,897 | 644,283 | 2.27 | 3 | 60 | 3,916,640 | 164.5 |
| Spain | 105,624,359 | 6,330,651 | 5.99 | 29.7 | 134 | 23,913,680 | 264.7 |
| France | 310,373,987 | 1,291,230 | 0.42 | 6.1 | 19 | 27,364,630 | 47.2 |
| Croatia | 6,003,760 | 565,300 | 9.42 | 2.7 | 140 | 1,505,430 | 375.5 |
| Italy | 174,887,620 | 348,501 | 0.20 | 1.6 | 6 | 12,523,540 | 27.8 |
| Cyprus | 2,221,809 | 21,156 | 0.95 | 0.1 | 24 | 134,140 | 157.7 |
| Latvia | 2,852,792 | 133,282 | 4.67 | 0.6 | 70 | 1,968,960 | 67.7 |
| Lithuania | 6,695,731 | 301,722 | 4.51 | 1.4 | 108 | 2,914,550 | 103.5 |
| Luxembourg | 9,215,222 | 11,445 | 0.12 | 0.1 | 18 | 132,140 | 86.6 |
| Hungary | 17,150,400 | 295,281 | 1.72 | 1.4 | 30 | 4,921,740 | 60.0 |
| Malta | 3,528,663 | 11,851 | 0.34 | 0.1 | 23 | 9,800 | 1209.3 |
| Netherlands | 125,138,771 | 4,896,548 | 3.91 | 22.9 | 281 | 1,817,900 | 2693.5 |
| Austria | 68,906,034 | 168,233 | 0.24 | 0.8 | 19 | 2,602,670 | 64.6 |
| Poland | 170,233,670 | 281,119 | 0.17 | 1.3 | 7 | 14,784,120 | 19.0 |
| Portugal | 16,601,514 | 94,347 | 0.57 | 0.4 | 9 | 3,963,940 | 23.8 |
| Romania | 141,364,457 | 720,130 | 0.51 | 3.4 | 37 | 12,762,830 | 56.4 |
| Slovenia | 7,518,375 | 55,730 | 0.74 | 0.3 | 27 | 483,440 | 115.3 |
| Slovakia | 12,775,926 | 562,354 | 4.40 | 2.6 | 103 | 1,862,650 | 301.9 |
| Finland | 116,082,531 | 0 | 0 | 0 | 0 | 2,281,710 | 0 |
| Sweden | 151,823,910 | 1,045,928 | 0.69 | 4.9 | 101 | 3,005,810 | 348.0 |
| Avarage EU 27 | 79,775,844 | 790,804 | 1.83 | 3.7 | 63 | 5,830,211 | 269.1 |

*Source: Own calculations based on Eurostat data*

When relating the total waste generated by all economic activities (TW) of the EU member states with the waste generated by agriculture, forestry and fisheries (AFF) of those countries, it is noticeable that the latter represents a very small share. In that sense, Croatia was the member state that registered the highest share of AFF from the country`s TW with 9.24%, while Spain and Slovakia`s AFF share of their TW comprised for around 5.99% and 4.40% respectively. The share of Bulgaria`s AFF waste generated of the country`s total waste generated by all economic activities was 0.77%, which was twice below the EU average level of 1.82%. For countries like Poland and Luxemburg, the AFF waste represented an insignificant share of the countries` TW, comprising of just 0.17% and 0.12% respectively.

Once again Spain and the Netherlands were the countries with the highest percentage of the total AFF waste generated in the EU in 2020, with an average of 3.70% per EU member

states. Countries like Slovenia, Portugal, Austria, Malta, Luxembourg, Latvia, Cyprus and Estonia remained below the EU average level with AFF share in the total EU AFF waste generated under 1%. Bulgaria on the other hand remained above the EU average level with a share of 4.18% in the total AFF waste generated in the EU.

The EU total AFF waste measured in kilogram per hectare of utilized agricultural area (kg/h UAA) in 2020 was 135.6 kg/h with an EU average of 269.1kg/h per member state. The Netherlands and Malta were the member states that registered the highest value of the observed indicator, with other countries registering significant amount of AFF waste per kg/h UAA included Sweden and Croatia. The AFF waste per kg/h UAA measured in Bulgaria was 195.6 kg/h., which was below the average for the EU member states.

AFF waste measured in kilogram per capita in 2020 in the whole EU was 48 kg., with an EU average of 63 kg per member state. The Netherlands was the member state that generated the most AFF waste per capita, while Croatia and Estonia reported 140 kg and 147 kg of AFF waste per capita in 2020. Bulgaria also generated a significant amount of AFF waste per capita, which ranked it 5th among all EU member states in 2020, including above the EU average by 66 kg.

Table 4 presents data on the total agricultural, forestry and fishery (AFF) waste generated in the EU member states for 2016 in tons. They amounted to more than 20.1M tons generated in total, averaging more than 745 738 tons per country.

Spain and the Netherlands were the member states that generated the highest amount of AFF waste in 2016, while France and Germany reported amounts of around 1M tons. Bulgaria also generated a significant amount of AFF waste and ranked 7th in the EU below the EU average in 2016.

On the other hand, Malta was the member state that generated the smallest amount AFF waste in 2016 with Cyprus and Luxemburg also reporting low values of the observed indicator.

The total amount of animal and vegetal (AVW) waste generated by the EU member states in 2016 was around 17M tons, averaging more than 3.70 % per country with Spain and the Netherlands being the countries that represented the highest share of the EU AVW waste among all member states. Bulgaria`s share of the EU AVW waste on the other hand remained around the EU average, comprising of 3.40%.

Again, it was Spain and the Netherlands being the member states that generated the highest amount of AVW waste in 2016, while France and Germany reported almost equal amounts of around 700,000 tons. Bulgaria also generated a significant amount of AVW waste and ranked 7th in the EU with 52 089 tons below the EU average in 2016.

Cyprus was the member state that generated the least AVW waste in 2016 with Malta and Ireland also reporting low values of the observed indicator.

When relating the total waste generated by agriculture, forestry and fisheries (AFF) by the EU member states with the animal and vegetal (AVW) waste generated by those countries, it is noticeable that the latter represents a major share for almost every state. In that sense, Croatia was the member state that registered the highest share of AVW waste in the country`s total AFF waste with 98.02%, while Spain, Slovakia, Romania, the Netherlands, Malta,

Hungary, Luxemburg, Greece and Bulgaria all registered higher than 90% share of the AVW waste in the total AFF waste generated. An exception were those countries, such as the Czech Republic, Ireland, Italy and Latvia, where the share of AVW waste in the total AFF waste generated was significantly lower, representing around 25%, 11.45%, 24.46% and 16.16% respectively.

***Table 4. EU Member States' agricultural, forestry and fisheries (AFF) waste for 2016 (t)***

| Country | AFF Waste (t) | Animal and vegatal waste (AVW) (t) | | | | Share of the total AFF Waste (%) | % of AVW, EU27 = 100 % | KG/HUAA |
|---|---|---|---|---|---|---|---|---|
| | | Total AVW (t) | Animal and mixed food waste | Vegetal Wastes | Animal faeces, urine and manure | | | |
| EU 27 (2020) | 20,130,000 | 17,020,000 | 860,000 | 4,080,000 | 12,080,000 | 84.55 | 100 | 108.6 |
| Belgium | 269,190 | 139,972 | 14,373 | 125,452 | 147 | 52 | 0.82 | 103.4 |
| Bulgaria | 617,689 | 578,000 | 1,876 | 172,855 | 403,269 | 93.6 | 3.40 | 128.7 |
| Czechia | 114,575 | 28,647 | 7,636 | 21,011 | 0 | 25 | 0.17 | 8.3 |
| Denmark | 201,648 | 110,732 | 1,867 | 73,975 | 34,890 | 54.9 | 0.65 | 42.4 |
| Germany | 1,126,134 | 766,369 | 57,786 | 343,124 | 365,459 | 68.1 | 4.50 | 45.8 |
| Estonia | 113,946 | 79,759 | 777 | 26,214 | 52,768 | 70 | 0.47 | 80.2 |
| Ireland | 105,033 | 12,030 | 12,030 | 0 | 0 | 11.5 | 0.07 | 2.5 |
| Greece | 255,169 | 234,264 | 5,105 | 73,708 | 155,451 | 91.8 | 1.38 | 51.4 |
| Spain | 6,271,464 | 5,730,082 | 191,731 | 796,416 | 4,741,935 | 91.4 | 33.67 | 246.7 |
| France | 1,303,642 | 775,466 | 471,987 | 3,479 | 300,000 | 59.5 | 4.56 | 27.9 |
| Croatia | 496,153 | 486,305 | 11 | 10,830 | 475,464 | 98 | 2.86 | 311.1 |
| Italy | 320,928 | 78,487 | 8,021 | 53,673 | 16,793 | 24.5 | 0.46 | 6.2 |
| Cyprus | 19,453 | 9,336 | 8,203 | 1,133 | 0 | 48 | 0.05 | 83.4 |
| Latvia | 144,075 | 23,284 | 0 | 23,284 | 0 | 16.2 | 0.14 | 12.1 |
| Lithuania | 280,625 | 246,958 | 1,899 | 216,738 | 28,321 | 88 | 1.45 | 84.4 |
| Luxembourg | 30,890 | 29,401 | 4 | 7,944 | 21,453 | 95.2 | 0.17 | 225.0 |
| Hungary | 484,320 | 450,723 | 7,455 | 51,436 | 391,832 | 93.1 | 2.65 | 96.5 |
| Malta | 10,565 | 10,034 | 822 | 286 | 8,926 | 95 | 0.06 | 897.5 |
| Netherlands | 5,085,249 | 4,647,019 | 529 | 1,328,386 | 3,318,104 | 91.4 | 27.30 | 2587.1 |
| Austria | 129,834 | 59,072 | 5,960 | 6,792 | 46,320 | 45.5 | 0.35 | 22.1 |
| Poland | 534,931 | 467,314 | 12,549 | 121,886 | 332,879 | 87.4 | 2.75 | 32.4 |
| Portugal | 55,520 | 20,359 | 8,978 | 3,719 | 7,662 | 36.7 | 0.12 | 5.6 |
| Romania | 507,712 | 482,285 | 0 | 482,285 | 0 | 95 | 2.83 | 38.6 |
| Slovenia | 63,248 | 52,466 | 3,498 | 1,545 | 47,423 | 83 | 0.31 | 107.4 |
| Slovakia | 788,559 | 748,060 | 3,336 | 131,347 | 613,377 | 94.9 | 4.40 | 395.8 |
| Finland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Sweden | 804,382 | 745,977 | 30,280 | 0 | 715,697 | 92.7 | 4.38 | 246.9 |
| Avarage EU 27 | 745,738 | 630,089 | 31,730 | 151,019 | 447,340 | 66.7 | 3.70 | 218.1 |

*Source: Own calculations based on Eurostat data*

Moreover, if further decomposing the category of animal and vegetal (AVW) waste generated in 2016 into three subcategories (animal and mixed food waste; vegetal waste and animal faeces, urine and manure), it should be noted that the animal faeces, urine and manure represented the highest of all amount, followed by the vegetal waste and animal and mixed food waste.

France and Spain were the member states that generated the highest amount of animal and mixed food waste in 2016, while Germany and Sweden also reported significant amounts of waste generation. On the contrary, Luxemburg and Croatia were the countries generating the lowest amount of animal and mixed food waste, with Romania and Latvia not generating such waste at all. Bulgaria, on the other hand, also generated a low amount of animal and mixed food waste of just 1 876 tons, far below the EU average level.

The Netherlands and Spain topped the list of the member states that generated the highest amount of vegetal waste. Other countries reporting high amounts of waste generation included Germany and Romania, which were lower than the waste generated by the Netherlands and Spain, but significant compared to the other EU member states. Malta, on the other hand, was the member state that generated the lowest amount of vegetal waste in 2016 with Sweden and Ireland not generating such type of waste at all. As regards to Bulgaria, the country generated 172 855 tons of vegetal waste in 2016 (which is slightly above the EU average) and ranked 6th among all EU member states.

Furthermore, the Netherlands and Spain were also the countries that generated the highest amounts of waste from animal faeces, urine and manure with other member states including Sweden and Slovakia. Although the latter amounts were significantly lower than those generated by the Netherlands and Spain, they were significantly higher compared to the waste generated by the other EU member states. Belgium, on the other hand, was the member state that generated the lowest amount of waste from animal faeces, urine and manure in 2016 with Romania, Latvia, Cyprus, Ireland and the Czech Republic not generating such type of waste at all. As regards Bulgaria, the value of the examined indicator represented an amount of 403 269 tons of waste generated from animal faeces, urine and manure, which was around the EU average as the country again ranked 6th among all EU member states in 2016.

When relating the total animal and vegetal (AVW) waste generated by the EU member states to its decomposed subcategories – animal and mixed food waste; vegetal waste and animal faeces, urine and manure, it is noticeable that the latter subcategory represents a major share in the AVW waste in almost every country. The exceptions were the Czech Republic, Latvia, Lithuania, Italy and Romania where the AVW waste consisted mainly of vegetal waste. There was one more distinctive exception – the case of Ireland and Cyprus, where the AVW waste mainly consisted of animal and mixed food waste with Ireland not generating waste from the other two subcategories at all.

The EU total AVW waste measured in kilogram per hectare of utilized agricultural area (kg/h UAA) in 2016 was 108.6 kg/h with an EU average of 218.1kg/h per member state. In that sense, the Netherlands was the member state that registered the highest value of the observed indicator. This can be explained by the high amount of waste generated on a relatively small utilized agricultural area. For Bulgaria, the AVW waste per kg/h UAA in 2016 was 128.7 kg/h., which was almost twice below the EU member states average value.

Table 5 presents data on the total agricultural, forestry and fishery (AFF) waste generated in the EU member states in 2018 in tons. They amounted to more than 20.1M tons generated in total, averaging 746 594 tons per country.

***Table 5. EU Member States' agricultural, forestry and fisheries (AFF) waste for 2018 (t)***

| Country | AFF Waste (t) | Animal and vegatal waste (AVW) (t) | | | | Share of the total AFF Waste (%) | % of AVW, EU27 = 100 % | KG/H UAA |
|---|---|---|---|---|---|---|---|---|
| | | Total AVW (t) | Animal and mixed food waste | Vegetal Wastes | Animal faeces, urine and manure | | | |
| EU 27 (2020) | 20,160,000 | 16,630,000 | 1,120,000 | 4,010,000 | 11,500,000 | 82.5 | 100 | 106.2 |
| Belgium | 362,508 | 177,146 | 16,406 | 160,740 | 0 | 48.9 | 1.07 | 130.8 |
| Bulgaria | 308,760 | 277,069 | 2,826 | 167,696 | 106,547 | 89.7 | 1.67 | 61.7 |
| Czechia | 411,533 | 121,830 | 2,873 | 61,415 | 57,542 | 29.6 | 0.73 | 35.3 |
| Denmark | 373,978 | 288,466 | 3,290 | 48,506 | 236,670 | 77.1 | 1.73 | 110.3 |
| Germany | 982,106 | 685,468 | 52,871 | 416,274 | 216,323 | 69.8 | 4.12 | 41.0 |
| Estonia | 138,195 | 94,030 | 689 | 24,257 | 69,084 | 68 | 0.57 | 94.5 |
| Ireland | 296,865 | 205,353 | 205,353 | 0 | 0 | 69.2 | 1.23 | 42.0 |
| Greece | 466,119 | 396,385 | 4,538 | 19,616 | 372,231 | 85 | 2.38 | 87.0 |
| Spain | 6,258,251 | 5,718,373 | 191,092 | 815,508 | 4,711,773 | 91.4 | 34.39 | 246.2 |
| France | 1,309,912 | 764,998 | 464,548 | 450 | 300,000 | 58.4 | 4.60 | 27.5 |
| Croatia | 550,471 | 539,304 | 14 | 2,458 | 536,832 | 98 | 3.24 | 345.0 |
| Italy | 332,554 | 70,438 | 6,133 | 53,252 | 11,053 | 21.2 | 0.42 | 5.6 |
| Cyprus | 19,783 | 10,501 | 9,380 | 1,121 | 0 | 53.1 | 0.06 | 93.8 |
| Latvia | 132,746 | 90,406 | 88,088 | 2,318 | 0 | 68.1 | 0.54 | 46.8 |
| Lithuania | 293,676 | 251,950 | 523 | 230,477 | 20,950 | 85.8 | 1.52 | 86.1 |
| Luxembourg | 8,330 | 3,950 | 17 | 3,933 | 0 | 47.4 | 0.02 | 30.2 |
| Hungary | 449,607 | 397,228 | 11,173 | 48,602 | 337,453 | 88.4 | 2.39 | 85.0 |
| Malta | 12,292 | 11,385 | 1,228 | 203 | 9,954 | 92.6 | 0.07 | 1018.3 |
| Netherlands | 4,678,699 | 4,186,120 | 321 | 1,216,629 | 2,969,170 | 89.5 | 25.17 | 2330.5 |
| Austria | 139,870 | 61,174 | 2,960 | 12,313 | 45,901 | 43.7 | 0.37 | 22.9 |
| Poland | 431,500 | 308,465 | 13,883 | 76,988 | 217,594 | 71.5 | 1.85 | 21.4 |
| Portugal | 62,073 | 10,613 | 321 | 2,821 | 7,471 | 17.1 | 0.06 | 2.9 |
| Romania | 584,619 | 559,509 | 0 | 559,509 | 0 | 95.7 | 3.36 | 44.8 |
| Slovenia | 61,665 | 52,735 | 255 | 639 | 51,841 | 85.5 | 0.32 | 108.0 |
| Slovakia | 529,786 | 446,383 | 3,091 | 87,623 | 355,669 | 84.3 | 2.68 | 236.2 |
| Finland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sweden | 962,141 | 902,526 | 34,087 | 0 | 868,439 | 93.8 | 5.43 | 298.7 |
| Avarage EU 27 | 746,594 | 615,993 | 41,332 | 148,643 | 426,018 | 67.5 | 3.70 | 209.4 |

*Source: Own calculations based on Eurostat data*

Spain and the Netherlands were the member states that generated the highest amount of AFF waste in 2018, followed by France, while Germany and Sweden reported similar amounts. Bulgaria`s AFF waste generated is less than half of the EU average and amounts to 308,760 tons.

On the other hand, Luxemburg was the member state that generated the smallest amount AFF waste in 2018 with Cyprus and Malta also reporting low values of the observed indicator.

The total amount of animal and vegetal (AVW) waste generated by the EU member states in 2018 was around 16.6M tons with Spain and the Netherlands being the countries that had the highest share of the EU AVW waste among all member states. Bulgaria`s share of the EU AVW waste on the other hand remained around twice below the EU average, comprising 1.67%.

Again, it was Spain and the Netherlands being the member states that generated the highest amount of AVW waste in 2018. Bulgaria, on the other hand, was among the countries that generated a relatively low amount of AVW waste, which was around twice below the EU average in 2018.

Luxemburg was the member states that generated the least AVW waste in 2018 with Portugal, Malta and Ireland also reporting low values of the observed indicator.

In that sense, Croatia was the member state that registered the highest share of AVW waste in the country`s total AFF waste with 97.97%, while Sweden, Romania, Malta and Spain all registered higher than 90% share of the AVW waste in the total AFF waste generated. An exception were those countries, such as the Czech Republic, Italy and Portugal, where the share of AVW waste in the total AFF waste generated was significantly lower. Bulgaria, in turn, followed the EU general trend with an 89.74% share of the AVW waste in the total AFF waste generated by the country.

Moreover, if further decompose the category of animal and vegetal (AVW) waste generated in 2018 into three subcategories (animal and mixed food waste; vegetal waste and animal faeces, urine and manure), it should be noted that the animal faeces, urine and manure represented the highest of all amount, followed by the vegetal waste and animal and mixed food waste.

France, Ireland and Spain were the member states that generated the highest amount of animal and mixed food waste in 2018, while Germany and Sweden also reported significant amount of waste generation. On the contrary, Luxemburg and Croatia were the countries generating the lowest amount of animal and mixed food waste. Bulgaria, on the other hand, also generated a low amount of animal and mixed food waste of just 2,826 tons, far below the EU average level.

The Netherlands and Spain topped the list of the member states that generated the highest amount of vegetal waste. Other countries reporting high amounts of waste generation included Germany and Romania, which were lower than the waste generated by the Netherlands and Spain, but significant compared to the other EU member states. Malta, on the other hand, was the member state that generated the lowest amount of vegetal waste in 2018 with Sweden and Ireland not generating such type of waste at all. As regards Bulgaria, the country generated 167,696 tons of vegetal waste in 2018 (which is slightly above the EU average) and ranked 6th among all EU member states.

Furthermore, the Netherlands and Spain were also the countries that generated the highest amounts of waste from animal faeces, urine and manure with other member states generating

high amounts included Sweden and Croatia. Although the latter amounts are significantly lower than those generated by the Netherlands and Spain, they were significantly higher compared to the waste generated by the other EU member states. Portugal, Malta and Italy on the other hand, were the member states that generated the lowest amount of waste from animal faeces, urine and manure in 2018 with Romania, Luxemburg, Latvia, Cyprus, Ireland and Belgium not generating such type of waste at all. As regards Bulgaria, the value of the examined indicator represented an amount of 106 547 tons of waste generated from animal faeces, urine and manure, which was far below the EU average.

The exceptions were Belgium, Germany, Lithuania, Italy, Luxemburg and Romania where the AVW waste consisted mainly of vegetal waste. There was one more distinctive exception – the case of Ireland and Cyprus, where the AVW waste consisted mainly of animal and mixed food waste with Ireland not generating waste from the other two subcategories at all.

The EU total AVW waste measured in kilogram per hectare of utilized agricultural area (kg/h UAA) in 2018 was 106.2 kg/h with an EU average of 209.4 kg/h per member state. The Netherlands was the member state that registered the highest value of the observed indicator, followed by Malta. For the Netherlands, this can be explained by the high amount of waste generated on a relatively small utilized agricultural area. For Bulgaria, the AVW waste per kg/h UAA in 2018 was 61.7 kg/h., which was one of the lowest values registered in the entire EU.

Table 6 presents data on the total agricultural, forestry and fishery (AFF) waste generated in the EU member states in 2020 in tons. They amounted to more than 21.3M tons generated in total, averaging 790,804 tons per country.

Spain and the Netherlands were the member states that generated the highest amount of AFF waste in 2020, followed by France, while Sweden and Germany both reported similar amounts of more than 1M tons. Bulgaria also generated a significant amount of AFF waste in 2020 as the country ranked 6th among the EU member states and above the EU average by 101,960 tons.

On the other hand, Malta and Luxemburg were the member states that generated the smallest amount of AFF waste in 2020 with Cyprus also registering low values of the observed indicator.

The total amount of animal and vegetal (AVW) waste generated by the EU member states in 2020 was around 17.5M tons (averaging 648,241 tons per country) with Spain and the Netherlands being the countries that had the highest share of the EU AVW waste among all member states. Bulgaria`s share of the EU AVW waste on the other hand remained above the EU average level, comprising of 4.65%.

Again, it was Spain and the Netherlands being the member states that generated the highest amount of AVW waste in 2020. Bulgaria, on the other hand, also generated a high amount of AVW waste, which was above the EU average in 2020 by 167,531 tons, ranking 4th among all EU member states.

***Table 6. EU Member States' agricultural, forestry and fisheries (AFF) waste for 2020 (t)***

| Country | AFF Waste (t) | Animal and vegatal waste (AVW) (t) | | | | Share of the total AFF Waste (%) | % of AVW, EU27 = 100 % | KG/H UAA |
|---|---|---|---|---|---|---|---|---|
| | | Total AVW (t) | Animal and mixed food waste | Vegetal Wastes | Animal faeces, urine and manure | | | |
| EU 27 (2020) | 21,350,000 | 17,550,000 | 1,020,000 | 4,100,000 | 12,430,000 | 82.2 | 100 | 111.5 |
| Belgium | 417,301 | 142,160 | 12,540 | 128,592 | 1,028 | 34.1 | 0.81 | 103.9 |
| Bulgaria | 892,764 | 815,772 | 1,373 | 234,709 | 579,690 | 91.4 | 4.65 | 178.7 |
| Czechia | 398,041 | 113,387 | 14,655 | 48,743 | 49,989 | 28.5 | 0.65 | 32.5 |
| Denmark | 389,498 | 288,068 | 6,188 | 50,779 | 231,101 | 74 | 1.64 | 109.5 |
| Germany | 1,004,332 | 627,724 | 73,107 | 277,978 | 276,639 | 62.5 | 3.58 | 37.8 |
| Estonia | 195,258 | 152,932 | 799 | 28,835 | 123,298 | 78.3 | 0.87 | 156.8 |
| Ireland | 275,414 | 190,804 | 190,804 | 0 | 0 | 69.3 | 1.09 | 38.8 |
| Greece | 644,283 | 574,856 | 4,581 | 38,778 | 531,497 | 89.2 | 3.28 | 146.8 |
| Spain | 6,330,651 | 5,778,781 | 193,114 | 819,554 | 4,766,113 | 91.3 | 32.93 | 241.7 |
| France | 1,291,230 | 750,421 | 450,087 | 334 | 300,000 | 58.1 | 4.28 | 27.4 |
| Croatia | 565,300 | 556,013 | 12 | 1,386 | 554,615 | 98.4 | 3.17 | 369.3 |
| Italy | 348,501 | 47,806 | 2,108 | 45,424 | 274 | 13.7 | 0.27 | 3.8 |
| Cyprus | 21,156 | 11,185 | 9,940 | 1,245 | 0 | 52.9 | 0.06 | 83.4 |
| Latvia | 133,282 | 45,647 | 8,836 | 36,811 | 0 | 34.3 | 0.26 | 23.2 |
| Lithuania | 301,722 | 259,468 | 391 | 249,043 | 10,034 | 86 | 1.48 | 89.0 |
| Luxembourg | 11,445 | 6,527 | 0 | 6,527 | 0 | 57 | 0.04 | 49.4 |
| Hungary | 295,281 | 272,387 | 9,509 | 2,536 | 260,342 | 92.3 | 1.55 | 55.3 |
| Malta | 11,851 | 11,251 | 1,585 | 197 | 9,469 | 94.9 | 0.06 | 1148.1 |
| Netherlands | 4,896,548 | 4,412,207 | 213 | 1,221,013 | 3,190,981 | 90.1 | 25.14 | 2427.1 |
| Austria | 168,233 | 94,651 | 2,597 | 23,473 | 68,581 | 56.3 | 0.54 | 36.4 |
| Poland | 281,119 | 98,121 | 3,895 | 42,690 | 51,536 | 34.9 | 0.56 | 6.6 |
| Portugal | 94,347 | 41,317 | 1,734 | 8,277 | 31,306 | 43.8 | 0.24 | 10.4 |
| Romania | 720,130 | 699,920 | 0 | 699,920 | 0 | 97.2 | 3.99 | 54.8 |
| Slovenia | 55,730 | 123 | 123 | - | - | 0.2 | 0 | 0.3 |
| Slovakia | 562,354 | 515,613 | 4,588 | 88,585 | 422,440 | 91.7 | 2.94 | 276.8 |
| Finland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sweden | 1,045,928 | 995,375 | 28,486 | 42,709 | 924,180 | 95.2 | 5.67 | 331.2 |
| Avarage EU 27 | 790,804 | 648,241 | 37,825 | 157,621 | 476,274 | 63.5 | 3.69 | 223.7 |

*Source: Own calculations based on Eurostat data*

In that sense, Croatia was the member state that registered the highest share of AVW waste in the country`s total AFF waste with 98.36%, while Sweden, Slovakia, Romania, the Netherlands, Malta, Hungary, Spain and Bulgaria all registered higher than 90% share of the AVW waste in the total AFF waste generated. An exception were those countries, such as Slovenia, Italy and the Czech Republic where the share of AVW waste in the total AFF waste generated was significantly lower.

Moreover, if further decompose the category of animal and vegetal (AVW) waste generated in 2020 into three subcategories (animal and mixed food waste; vegetal waste and animal faeces, urine and manure), it should be noted that the animal faeces, urine and manure

represent the highest of all amount, followed by the vegetal waste and animal and mixed food waste.

France was the member states that generated the highest amount of animal and mixed food waste in 2020, while Spain and Ireland also reported significant amount of waste generation. On the contrary, Croatia was the country that generated the lowest amount of animal and mixed food waste in 2020, with Romania and Luxemburg not generating such waste at all. Bulgaria, on the other hand, also generated a low amount of animal and mixed food waste of just 1 373 tons, far below the EU average level.

The Netherlands, Spain and Romania topped the list of the member states that generated the highest amount of vegetal waste. Other countries reporting high amounts of waste generation included Germany and Lithuania, which were lower than the waste generated by the Netherlands, Spain and Romania, but significant compared to the other EU member states. Malta, on the other hand, was the member state that generated the lowest amount of vegetal waste in 2020 with Ireland not generating such type of waste at all. As regards Bulgaria, the country generated 234,709 tons of vegetal waste in 2020 (which is almost twice above the EU average) and ranked 6th among all EU member states.

Furthermore, the Netherlands and Spain were also the countries that generated the highest amounts of waste from animal faeces, urine and manure with other member states generating high amounts included Sweden and Croatia. Although the latter amounts were significantly lower than those generated by the Netherlands and Spain, they were also significantly higher compared to the waste generated by the other EU member states. Italy, on the other hand, was the member state that generated the lowest amount of waste from animal faeces, urine and manure in 2020 with Romania, Luxemburg, Latvia, Cyprus and Ireland not generating such type of waste at all. As regards Bulgaria, the value of the examined indicator represented an amount of 579,690 tons of waste generated from animal faeces, urine and manure, which was above the EU average as the country ranked 4th among all EU member states for waste generation in 2020.

The exceptions were Belgium, Latvia, Lithuania, Italy, Luxemburg and Romania where the AVW waste consisted mainly of vegetal waste. There was one more distinctive exception – the case of Ireland and Cyprus, where the AVW waste consisted mainly of animal and mixed food waste with Ireland not generating waste from the other two subcategories at all.

The EU total AVW waste measured in kilogram per hectare of utilized agricultural area (kg/h UAA) in 2020 was 111.5 kg/h with an EU average of 223.7 kg/h per member state. The Netherlands was the member state that registered the highest value of the observed indicator, followed by Malta. For the Netherlands, this can be explained by the high amount of waste generated on a relatively small utilized agricultural area. For Bulgaria, the AVW waste per kg/h UAA in 2020 was 178.7 kg/h. – below the EU average.

France and Germany were the EU member states that generated the highest amounts of waste by all economic activities in the period 2016-2020. Both countries have registered an increase in the amount of waste generated over the years, with the exception of the year 2020, but although the data shows a decrease, the trend remains persistent. Other EU member states generating high and persistent amounts of waste by all economic activities included Italy and

Sweden. The amount of waste generated by Romania, Netherlands and Spain registered its peak in 2018, followed by a decrease by the end of the examined period. The only EU member state where there was a significant decrease in the amount of waste generated during the entire period from 2016 to 2020 was Poland. As regards Bulgaria, the country remained above the EU average level in terms of waste generated by all economic activities as the value of the indicator was gradually increasing over the examined period – the country ranked 10th in 2016 in terms of waste generated by all economic activities, then 9th in 2018 and 8th in 2020 among all EU member states. Latvia, Cyprus and Malta were the member states that generated the lowest amount of waste by all economic activities in the period 2016-2020 as the trend in Cyprus remained towards a decrease, while in Malta the trend followed the opposite direction and remained towards an increase.

When relating the total waste generated by all economic activities (TW) of the EU member states with the waste generated by agriculture, forestry and fisheries (AFF) of those countries in the period 2016-2020, it is noticeable that the latter represented a very small share in almost every country. In that sense, the highest share of AFF waste in the TW generated for the entire period is registered in Croatia with more than 9%, while the AFF share in the TW generated in Luxemburg, Italy and Poland was negligible.

Spain and the Netherlands possessed the highest share in the EU AFF waste generated during the period 2016-2020, as the figures suggest a downtrend. Germany, Sweden and France also generated significant amounts of AFF waste in the EU with Sweden registering an uptrend during the entire period. At the end of the period, Romania and Greece significantly increased the level of their AFF waste generated and ranked in the top ten EU countries with the highest values. Malta, Cyprus and Luxemburg, on the other hand, were the member states that generated the lowest amounts of agriculture, forestry and fisheries (AFF) waste in the entire EU for the period 2016-2020. Slovenia, Portugal, Latvia and Estonia also generated significantly low amounts of AFF waste comprising below 1% of the EU total AFF waste generated. Bulgaria`s AFF waste share remained mostly around the EU average level for the entire period with the exception of 2020 when an increase was registered, suggesting an uptrend.

Compared to 2016, there was an increase in the total animal and vegetal waste (AVW) generated by the EU member states in 2020. Spain and the Netherlands were the member states having the highest share of AVW generated although a declining trend was registered. Other member states generating high amounts of AVW included France and Sweden as a steady increase was registered during the entire period. Germany, on the other hand, generated significant amounts of AVW but the value of the examined indicator was constantly declining throughout the years. Romania`s AVW generated registered peak values in 2018 that continued to increase until the end of the examined period. Malta, Cyprus and Luxemburg were also the member states that generated the lowest amounts of animal and vegetal waste (AVW) in the entire EU for the period 2016-2020. Slovenia, Austria, Portugal, Latvia, Estonia, Italy and the Czech Republic also generated significantly low amounts of AVW waste comprising below 1% of the EU total AVW generated. Bulgaria`s AVW share remained mostly around the EU average level for the entire period with the exception of 2020 when an increase was registered, suggesting an uptrend.

When relating the EU member states AFF waste with the AVW generated for the period 2016-2020, it is noticeable that the latter represents a major share of the total AFF waste generated in almost every country. In that sense the highest share of AVW waste in the AFF waste generated for the entire period was registered in Croatia – 98%, while the AVW share in the AFF waste generated in Sweden, Romania, Bulgaria and Malta represented more than 90%. An exception to this tendency was the Czech Republic and Italy, where the AVW represented a minor share in the total AFF waste generated.

The total animal and vegetal waste consists of three subcategories. When relating the total animal and vegetal (AVW) waste generated by the EU member states to the animal and mixed food waste, vegetal waste and waste from animal faeces, urine and manure generated by those countries, it is noticeable that the latter subcategory represented a major share in the AVW waste in almost every country. The exceptions were Italy, Romania and Lithuania where the AVW waste consisted mainly of vegetal waste. There was one more distinctive exception – the case of Ireland and Cyprus, where the AVW waste mainly consisted of animal and mixed food waste with Ireland not generating waste from the other two subcategories at all.

France and Spain were the countries generating the highest amount of animal and mixed food waste in the EU for the period 2016-2020, although France`s trend was declining. Luxemburg and Croatia, on the other hand, were the member states that generated the lowest amount of animal and mixed food waste in the EU, with Luxemburg not generating this type of waste in 2020 at all. Romania, in addition, has not generated any animal and mixed food waste throughout the entire period, while Bulgaria`s value of the observed indicator remained far below the EU average level.

The Netherlands, Spain, Germany, and Romania were the EU member states that generated the highest amount of vegetal waste for the period 2016-2020. On the contrary, Malta was the country generating the lowest amounts, while Ireland did not generate such waste at all. As regards Bulgaria, the value of the analysed indicator remained slightly above the EU average throughout the entire period as the country ranked 6th among all EU member states. The Netherlands and Spain were also the countries generating the highest amount of waste from animal faeces, urine and manure as Sweden also generated significant amounts that constantly increased during the period 2016-2020. Romania, Latvia, Cyprus and Ireland, on the other hand, had not generated such waste at all. For Bulgaria, the value the value of the analysed indicator remained around the EU average with the country ranked 4th in the entire EU in 2020 in terms of waste generated from animal faeces, urine and manure.

The EU total AFF waste measured in kilogram per hectare of utilized agricultural area (kg/h UAA) for the period 2016-2020 has increased. The Netherlands and Malta were the member states that registered the highest value of the observed indicator, with Malta reporting a constant increase throughout the whole period. Sweden and Croatia also registered a constant increase in the analysed indicator from 2018 onwards, although the values were significantly lower than those of the Netherlands and Malta. Bulgaria, on the other hand, remained almost half below the EU average level. The EU total AVW waste measured in kilogram per hectare of utilized agricultural area (kg/h UAA) for the period 2016-2020 also increased. Again, it was the Netherlands and Malta being the member states that registered the highest value of the observed indicator, with Malta and Croatia reporting a constant increase throughout the whole period. For the Netherlands, this can be explained by the high amount of waste

generated on a relatively small utilized agricultural area. As for Bulgaria, the AVW waste measured in kilogram per hectare of utilized agricultural area remained around half below the EU average level, especially in 2018, when the country registered one of the lowest values in the entire EU. AFF waste measured in kilogram per capita for the entire EU for the period 2016-2020 had also increased with the Netherlands, Croatia and Spain being the leading member states. Bulgaria, on the other hand, also have generated a significant amount of AFF waste per capita ranking 5th among all EU member states in 2020.

## 3. Examples of innovative use of agricultural waste.

Good management of agricultural waste is a prerequisite for creating a valuable source of raw materials, the scarcity of which has become more significant each year. Effective management of agricultural waste also contributes to economic growth and reduction of unemployment rate (Georgieva, 2023), (Ivanova, 2018). It is therefore necessary to highlight different and applicable methods for recycling and re-utilisation of agricultural waste. Some of them have been used for a long time while also being constantly updated. Others have been newly developed and are in the process of being tested. Nevertheless, all of these methods are aimed at protecting the environment and minimizing or completely eliminating agricultural waste (Doitchinova, Stoyanova, 2023). The effective impact of innovation on economic development is closely linked to the legal, institutional and financial environment. They have an impact on all the economic agents that transform existing and newly created knowledge into advanced competitive products and services for the market (Chobanova, Ilieva-Naydenova, Bakardzhieva, 2005). The extent to which innovative solutions are adopted varies independently by each country. Factors that influence this decision include the country's national policy, the level of awareness regarding the innovations being offered, the financial status of agricultural producers, and other specific national characteristics (such as mentality, religion and traditions) (Branzova, Dimitrova, Blagoev, 2024).

Environmental protection is a relatively separate part of agricultural activities. This also applies to environmentally friendly waste collection, waste storage and disposal, organic production, etc. Usually, environmental protection is related to the overall management of the farm or its individual functional areas – investments, labour, land use, cultivation and protection of plants, etc. (Bachev, Yovchevska, Mitova, Toteva, Mitov, 2013).

- Application of sewage sludge.

The use of sludge in agriculture is an economically efficient and environmentally friendly method. It reduces the costs of sludge treatment. The use of sludge also contributes to restoring and improving soil quality and reducing soil erosion (Ivanova, 2018). The sludge is transported by trucks as heavy agricultural machinery is used for spreading and ploughing. That in turn damages the soil. Moreover, as a result of the densification, no yield effect is registered during the first year. In the case of cereals (wheat and barley), a positive change has been reported after the third year. The final outcome of sludge application in farms occurs during the fourth year (Bashev, Ivanov, 2021).

The effects of sludge utilization include different types – production and agronomic, social, ecological and economic. Economic effects include reduction of production costs, working capital requirement and the need for borrowed capital. They also include an increase in the income and in the transaction costs. The use of sludge in the farm also serves as an alternative to expensive mineral fertilizers. In that way, the output registers greater profit and the farm increases its efficiency. (Bashev, Ivanov, 2021).

The use of sludge also raises the income, financial capabilities, competitiveness and economic sustainability of the farm. That in turn leads to a higher social sustainability as it provides employment in the area (Blagoev, 2023).

Several countries, such as the Netherlands, Sweden, Denmark, and Germany, have successfully implemented the reuse of wastewater sludge. The Directive encourages the utilization of sludge in agriculture, recognizing its valuable properties, while stipulating that it can only be used in areas where it does not have a negative impact on soil quality and agricultural products.

- Application of sludge from poultry farms` organic fertilizers.

The use of calcareous sludge in combination with sludge from poultry farms` organic fertilizers is a method of integrated utilization of several types of waste. After being dried in order to reach the desired level of humidity (without the need for special measures), the waste can be used as a soil improver. The product obtained possesses an alkaline reaction (pH) that allows it to be used for acidic soil treatment.

The purpose of the calcareous sludge is to destroy the bioactive components of organic fertilizers, thus preventing the emission of odorous gases. It stabilizes and decontaminates the waste, thereby improving its composition and properties, as this is a prerequisite for wider use of sludge from poultry farms` organic fertilizers in plant farms (Stoyanov, Petkova, Serafimova, 2019).

For example, in Bangladesh, it is common practice to collect poultry waste in bags and subsequently use it directly as fertilizer in agricultural fields and aquaculture.

- Carbon utilization of waste (through composting).

The process of composting is one of the most frequently applied technological schemes and technical systems for regenerative carbon utilization of agricultural waste – through activated composting in closed containers in order to guarantee the sanitization of the final product. It is carried out in accordance with the provisions of both Bulgarian and European legislation. The developed three-section closed rotary system for activated composting guarantees the rapid development of a thermophilic phase that is necessary for the complete sanitation of the final product on the one hand, and, on the other hand – the shorter period (28 days) for the complete finalisation of the composting process (Zhechko, Yanev, Pelovski, Serafimova, 2022).

The process of composting is a cornerstone of the strategy aimed at limiting and minimizing agricultural waste. Fruit farming (as a sub-sector of agriculture) is among the major waste generators, including a significant amount of discarded production. By converting unsaleable

production into a new organic resource, fruit farming can perform more efficiently (Ananieva, 2022).

In countries such as South Korea, Taiwan, and Japan, local laws and regulations that support the use of food waste for animal feed comprise 72.1%, 33%, and 81% of the total food waste generated, respectively.

- Application of eggshells.

The egg product treatment and production generate significant amounts of waste, consisting mainly of shells. Discarded eggshells amount to 8 million tons per year worldwide. By 2030, this amount is expected to increase to about 9 million tons, so there is great potential in utilizing them (Hembrick-Holloman, Samuel, Mohammed, Jeelani, Rangari, 2020). They can be used for the production of fertilizers (low content of toxic substances; they lower the pH and increase the calcium content of the soil); calcium tablets; bone substitutes (dental preparations, bone implants); heavy metal adsorbents; catalysts; composite materials; animal feed (limestone substitute); additives in the food industry (calcium enrichment of fresh milk, yoghurt, bread, biscuits, sausages, etc.) (Saraliev, Kolev, 2023). The potential application of egg membranes includes biomaterial for aiding skin wound healing. Moreover, the application of soluble egg membrane preparation facilitates the synthesis of type III collagen in the skin, which improves skin elasticity and reduces facial wrinkles (Shi, Zhou, Li, Guyonnet, Hincke, Mine, 2021).

An innovative membrane separation technology that enables the efficient separation of the membrane from the mineral shell without damaging the membrane has been implemented in Hungary. This technology can process 100 kg of eggshells per hour. The development team behind this innovation consists of researchers from Spain, Italy, Portugal, and Hungary.

- Biofuel production from vegetal and animal waste.

The utilization of biomass for energy purposes provides new opportunities for industrial development (Popov, 2020). Hydrogen has been described as a source of clean energy and as a potential substitute for fossil fuels. In order to become a sustainable alternative fuel, hydrogen has to be produced from cheap and readily accessible raw materials that are renewable. The combined decomposition of rennet whey and vegetable waste improves hydrogen production due to the complementary characteristics of the two substrates (Gomez-Romero et. al., 2014).

Anaerobic decomposition is an alternative method of biogas production involving the treatment of high organic waste. Compared to aerobic composting processes, anaerobic processes require lower operating energy and relatively low initial investment costs. Anaerobic decomposition of waste alone is not efficient enough. That is why a combined, joint co-decomposition is simultaneously applied with other organic substrates. The advantages of co-anaerobic decomposition in various organic wastes include increased methane yield, more efficient use of equipment and reduction of organic matter to the maximum extent (Lin, et. al., 2011).

Biorefineries producing lignocellulosic bio-diesel are located in Norway, Germany, and Sweden. The residues that cannot be transformed into diesel are removed from the process

as harmless salts. More than 80% of the carbon dioxide contained in the raw materials is utilized.

- Production of biofertilizers from animal and vegetal waste.

Organic waste can be used as an alternative to synthetic fertilizers for stimulating plant growth. There are various microorganisms that have the ability to convert organic waste into valuable resources, thereby providing an opportunity for its safe disposal. The vegetal waste provides nutrients for microbial habitat and thus can be a potential alternative for transformation into an organic biofertilizer. Organic fertilizers are obtained as a result of the composting process. Composting and recycling food waste is part of the waste management strategy for preventing the use of synthetic fertilizers (Zhivkova, 2018).

In Spain, processing manure is a valuable asset for producing high-quality compost. Compost derived from animal waste can contribute to climate change mitigation by helping to retain water in farmlands.

- Production of fodder from animal and vegetal waste.

The search and application of new, non-conventional feeds, as an alternative to the traditional ones, is of increasing interest in order to satisfy the nutritional needs of animals and maintain their productivity. The wastes, generated during the production and processing of fruits and vegetables, represent an ecological threat during its landfilling and continuous accumulation. It shall be considered as a reliable source of nutrients and may be included in the composition of feed. The use of food waste in feed is an alternative of great interest as it has an environmental and social benefit and reduces the cost of animal husbandry. The implication of waste products into feed should be carried out with full assurance of their safety (Zhivkova, 2018).

In the United States, hemp seed pellets are utilized as an alternative feedstock for cattle. These pellets are rich in nutrients (proteins and fibres), contain low levels of cannabinoids, and are a suitable feed for animals.

## Conclusion

Waste generation is one of the modern world's main issues as its solutions are actively being sought. There are different methods aimed at limiting agricultural waste, some of which have been discussed in the current article. The results of the EU waste analysis for the selected period reaffirms the significance of the issue and the need for timely limitation and/or minimization of the generated waste.

Although the analysed data suggests that the agricultural sector is not a significant contributor to waste generation with a cumulative share of 0.91% of the total waste generated in the entire EU for the period 2016-2020, agricultural waste is crucial for the development of bioeconomy. Furthermore, it shall be noted that the main type of waste biomass produced in the agricultural sector comes from animal and vegetal waste, which accounts for more than 89% cumulatively of all the waste generated in the sector during the examined period.

Bulgaria, on the other hand, gradually increased its ranking in the EU in terms of total waste generated by all economic activities in the period 2016-2020, ranking 10th, 9th and 8th respectively. However, the country's share of agricultural waste in its total waste generated has fluctuated over the years, with a high of 0.77% in 2020 and a low of 0.24% in 2018. Despite the fluctuations, the overall trend indicates that agricultural waste generation is gradually increasing in Bulgaria, with a cumulative total of 1.8 million tons of agricultural waste generated from 2016 to 2020. This highlights the need for Bulgaria to implement more effective waste management strategies and to explore innovative approaches to utilize agricultural waste.

The analysis also highlights the importance of circular economy principles in reducing waste and promoting sustainable development. The EU's circular economy strategy aims to reduce waste generation and promote the use of recycled materials. Similarly, agricultural waste management should be integrated into the broader circular economy approach, with a focus on reducing waste, reusing and recycling materials. Innovative approaches to agricultural waste management can include the use of biotechnology, anaerobic digestion, and composting to convert organic waste into valuable products such as biofuels, fertilizers, and animal feed. These approaches can also help to reduce greenhouse gas emissions and promote sustainable agriculture practices.

In conclusion, the development of innovative approaches to agricultural waste management is crucial for Bulgaria and the European Union to achieve their environmental and sustainability goals. By implementing effective waste management strategies and promoting sustainable agriculture practices, we can reduce waste generation, promote circular economy principles, and contribute to a more sustainable future.

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