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EVALUATION

Evaluation of the Nitrates Directive (Council Directive 91/676/EEC)

{SWD(2026) 235 final}

ANNEX XIX. BIOGAS PRODUCTION AND THE USE OF DIGESTATES IN AGRICULTURE

This annex analyses the role of biogas production in the EU in relation to the Nitrates Directive rules on livestock manure and fertilisers. It is based on a study carried out in support of the evaluation[1].

Definition

Biogas production is the process of generating a renewable fuel, called biogas, by breaking down organic materials such as manure or crop residues by bacterial activity in the absence of oxygen. This happens inside a sealed system known as an anaerobic digester, where microorganisms naturally decompose the material and release a gas mixture mainly composed of methane (CH_4) and carbon dioxide (CO_2) along with smaller amounts of hydrogen sulfide (H_2S), water vapor, and other gases. This biogas can then be burned to produce heat and electricity in a combined heat and power (CHP) unit. Alternatively, it can be upgraded to biomethane to be injected into the gas grid or used directly as natural gas that is used for cooking, heating, or as a vehicle fuel. The remaining material after the digestion process, called **digestate**, is a nutrient-rich by-product that can often be used as fertilizer.

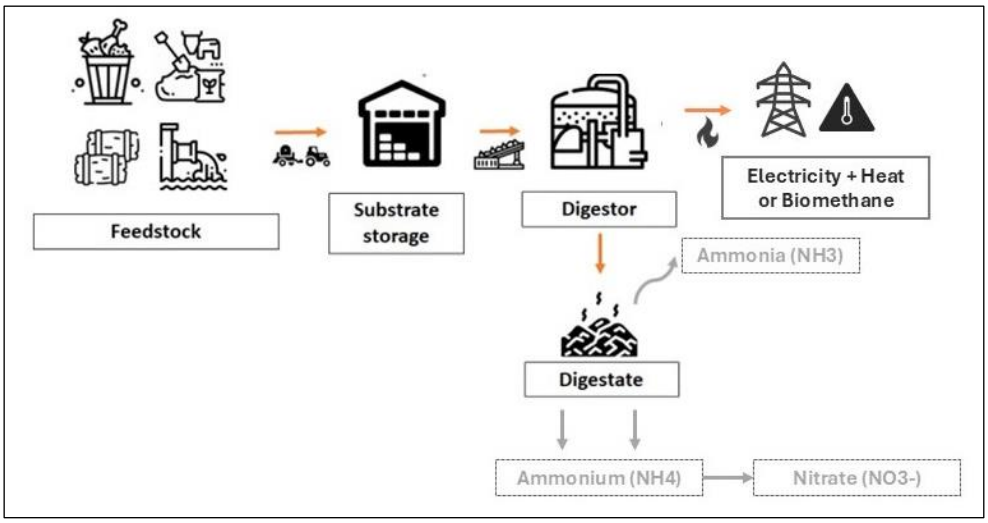
The consistency and nutrient composition of digestate depend on the type of feedstock, the input material used for the digestion process, as well as on process conditions. Nevertheless, digestate usually consists of organic matter, nitrogen, phosphorus, potassium, and other trace elements. It can be separated into a solid and a liquid phase, which and used for different purposes. During anaerobic digestion, much of the organic nitrogen in the feedstock is converted into ammonium (NH_4^+). Because the process occurs without oxygen, nitrate (NO_3^-) is not formed within the digester. However, when digestate is applied to soil as fertilizer, the ammonium can be oxidized to nitrate through microbial nitrification. Nitrate and ammonium are the main components of nitrogen fertilisers, both readily available to plants. Nitrate is also highly mobile in soils and can leach into groundwater. Ammonium can be lost to the atmosphere as ammonia gas if the digestate is not incorporated into the soil properly.

While anaerobic digestion converts a large part of the organic nitrogen from organic feedstocks into mineral nitrogen, the process is not complete, and some fraction remains in organic form. Therefore, digestates also remain rich in organic matter, retaining a certain amount of carbon. Depending on the feedstocks used, digestates can also contain various contaminants, which needs to be taken into account for their potential use as fertilisers. Both biogas and digestate can contribute to sustainable waste management and energy production, supporting circular economy principles by transforming waste into valuable resources. Digestate use is included in Fertilization Action Plan (2026) as a local source of nutrients and irrigation water. Within the Biomethane Industrial Partnership: the Commission, academia,

[1] ECORYS, "Complementary study to provide specific elements for the evaluation of the Nitrates Directive", 2026 (forthcoming).

farmers and industry have jointly developed a practical review[2] on digestate valorisation and best practice use.

Figure 1 Simplified scheme of biogas production process. Source: Adapted from JRC-Report 2024[3]



Expansion of biogas production in the EU

The biogas sector has expanded significantly in Europe over the past years. Biogas production is based on a variety of inputs, including agricultural and other waste streams such as **livestock manure**. The utilisation and valorisation of the digestates can represent an important income stream for the developing biogas sector. **Figure 2** below shows the estimated production of biogas digestates in Member States (MS), distinguishing between the parts that originate from livestock manure and other agricultural residues (e.g. straw) and those that come from various co-feedstocks (the main one being energy crops) [2].

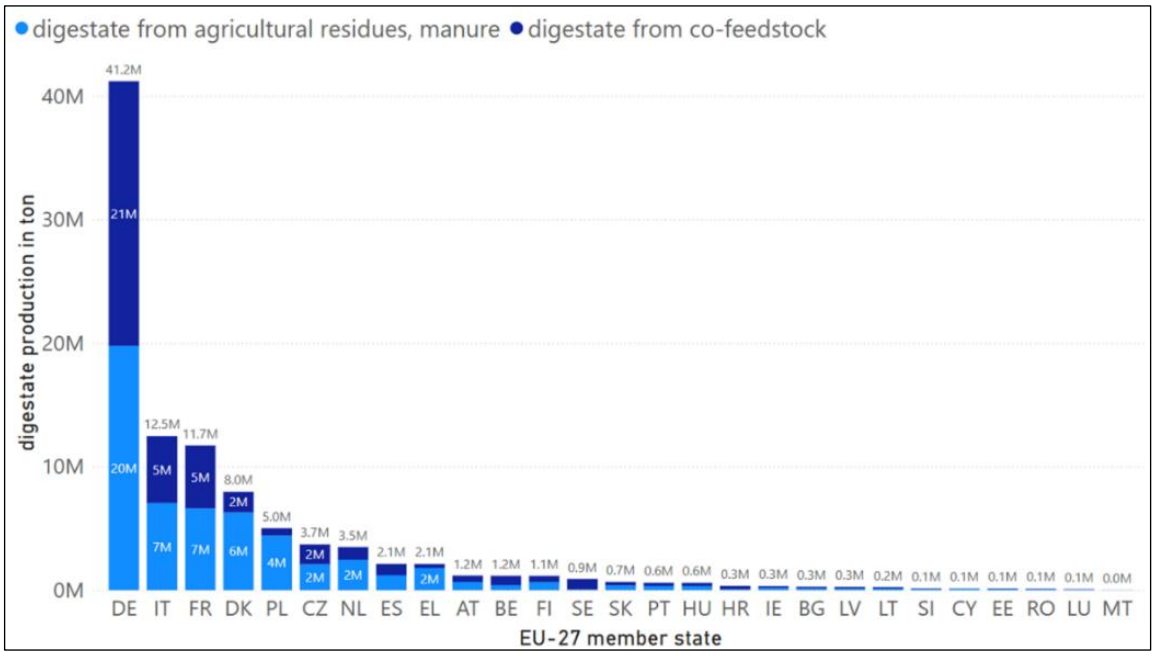
Currently, around 86% of digestate is disposed of on agricultural land, with 70% used without further treatment and 16% applied after first being upgraded. Upgrades involve processing methods that enhance transportability, storage, and fertiliser efficiency. Digestate is typically separated into liquid and solid fractions using screw presses or centrifuges. The remaining 14% is not applied to land and finds its use in horticulture, is biologically treated or landfilled [2]. Digestates can contain nutrients from agricultural origin (manure, residues), and nutrients from other feedstocks. While nutrients from agricultural origin are typically applied to land regardless of whether they are converted into digestate, other feedstocks (co-feed) are only used on agricultural land as fertiliser in digestate form. This effectively increases the total supply of organic nitrogen for agriculture, depending on the amount of co-

[2] Biomethane Industrial Partnership, The Task Force 2 co-chaired by DG GROW of the European Commission, EnviTec Biogas, and the European Waste Management Association (FEAD): Use and valorisation of digestates: a practical review, 2025.

[3] European Commission, Joint Research Centre (JRC), Buffi, M., Hurtig, O. and Scarlat, N., Methane emissions in the biogas and biomethane supply chains in the EU, Publications Office of the European Union, Luxembourg, 2024, https://data.europa.eu/doi/10.2760/7927411, JRC139485.

feedstock that is used in the anaerobic digestion process. It should be noted, that feedstocks based on crops (e.g. maize) also require fertiliser to be produced.

Figure 2 Yearly digestate production in tons by EU-27 Member State and by origin. Source: Ecorys, 2025[4].



Challenges to the use of digestates as fertiliser

As a fertiliser, digestate poses many of the same challenges as those associated with untreated manure, such as variability in nutrient concentrations, high bulk and water content, and inconsistency in nutrient release dynamics due to the slow mineralisation of organic nitrogen. Nevertheless, nutrients contained in digestate are generally more readily available for plant uptake than those in raw manure, improving overall nutrient use efficiency. During anaerobic digestion, between 20% and 95% of the organic matter in the feedstock is converted into biogas, while the remaining organic content contributes to the build-up of soil humus, supporting long-term soil fertility. However, the application of digestate carries both environmental benefits and risks.

Improper application may cause ammonia emissions and nitrate leaching particularly when applications are not synchronised with plant uptake. Furthermore, digestates can contain a variety of potentially harmful substances, depending on the feedstocks from which it is produced. Such substances may include heavy metals, antibiotic residues, organic micropollutants, and pathogens which can pose risks to both human health and ecosystems[5][6][7].

[4] Complementary study to provide specific elements for the evaluation of the ND (Council Directive 91/676/EEC), 2025.

[5] Czatzkowska, M.; Rolbiecki, D.; Korzeniewska, E.; Harnisz, M. Heavy Metal and Antimicrobial Residue Levels in Various Types of Digestate from Biogas Plants—A Review. Sustainability 2025, 17, 416.

[6] Wolak, I.; Bajkacz, S.; Harnisz, M.; Stando, K.; Męcik, M.; Korzeniewska, E. Digestate from Agricultural Biogas Plants as a Reservoir of Antimicrobials and Antibiotic Resistance Genes—Implications for the Environment. Int. J. Environ. Res. Public Health 2023, 20, 2672.

The risks depend in part on the feedstocks used. Heavy metals and antibiotic residues used for animal welfare and remaining in manure present either inhibitors or hazard to anaerobic digestion, reducing the crucial anaerobic bacteria needed to produce biogas. Therefore, a set of screening and pre-treatments are applied prior to feeding manure to the anaerobic digestor. Compared to the unprocessed manure, digestate has significantly lower weed seed germination rate, less pathogens and diluted heavy metal and antibiotic content. Sewage sludge digestate has to pass post-treatments to be applied on soil (BIP, 2025)[8]. Member States have developed their own national strategies and regulatory frameworks to address these risks since there is no harmonised regulation on digestate quality at EU-level. Some countries have introduced specific thresholds for contaminants in digestate used as fertiliser, while others have implemented certification schemes or restricted the use of certain feedstocks in anaerobic digestion processes (JRC, 2024; BIP, 2025). The considerable variability in feedstock types, processing methods, and application practices complicates the ability to draw generalised or quantitative conclusions regarding the overall effectiveness of digestates and their consequent risks in terms of nutrient losses.

To address environmental risks, the timing and rate at which digestate is applied need to be managed carefully to prevent losses of ammonia and nitrates. Application might need to be spread across different periods to prevent overloading the soil with nitrogen during any single application. Farmers may also adopt management practices such as incorporating digestate into the soil and using precision application techniques, to maximize nutrient uptake by crops and minimize potential losses to the environment. (See Annex XII on measures)

Legal compatibility with the Nitrates Directive

The Nitrates Directive treats digestate as any other fertiliser, which has to be considered when applying the balanced fertilisation principle [23]. The directive does not specifically limit the production or use of digestate, but it sets rules and conditions under which fertilisers, including digestates, can be used, with the aim to protect water quality. For instance, the codes of good agricultural practice that the directive requires, apply to the use of digestate. Farmers and operators using digestate must ensure that its application to land aligns with nutrient management practices, particularly concerning timing and quantity, to minimise leaching and runoff into water bodies. The ND sets restrictions on the amount of nitrogen that can be applied to land from organic and inorganic fertilizers, including digestate. This means that the nitrogen content of digestate will be a key factor in determining how much can be applied. Other measures under the ND also apply to digestates, where relevant, and Member

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7 See also Nkoa, R., 2014. Agricultural benefits and environmental risks of soil fertilization with anaerobic digestates: a review: R. Nkoa. Agronomy for Sustainable Development, 34(2), pp.473-492. Koszel, M. and Lorencowicz, E., 2015. Agricultural use of biogas digestate as a replacement fertilizers. Agriculture and Agricultural Science Procedia, 7, pp.119-124. Al Seadi, T. and Lukehurst, C., 2012. Quality management of digestate from biogas plants used as fertiliser. IEA bioenergy, 37, p.40.

8 Biomethane Industrial Partnership, The Task Force 2 co-chaired by DG GROW of the European Commission, EnviTec Biogas, and the European Waste Management Association (FEAD): Use and valorisation of digestates: a practical review, 2025.

States may include certain rules in the action programmes to address the specific characteristics of digestates.

The 170 kg of N/ha limit and its impact on the use of digestate

To the extent that the digestate is based on livestock manure, its use has to consider the livestock manure limit (see Annex XVII on the 170 kg/ha limit) in NVZs. Digestate derived from animal manure is regarded as manure under the Nitrates Directive and is therefore subject to the application limit of 170 kg N/ha in NVZs. The directive does not provide a specific approach to include digestate into that limit, leading to varied regulatory interpretations among Member States. Three main approaches exist:

- Integral Approach: All digestate is subject to the manure limit, regardless of feedstock (e.g. Germany).
- Manure Presence Approach: If manure is part of the feedstock, the entire digestate is counted under the manure limit. Digestate from non-manure sources is exempt (e.g. Denmark, the Netherlands, and Belgium-Flanders)
- Manure Proportion Approach: Only the manure-derived nutrient share counts towards the limit (e.g. France, Belgium-Wallonia, and Italy)

To comply with the limit, it is necessary to calculate the nitrogen content of the digestate and possibly to estimate the relative contribution of livestock manure, to ensure that its application does not exceed 170 kg of nitrogen per hectare per year (or whatever limit is set out in a derogation decision, where relevant). This requires testing and analysis of the digestate's nutrient profile (BIP, 2025)[9]. If the nitrogen content of digestate results in reaching the 170 kg/ha limit on a given farm, additional land may be required to spread the digestate without breaching regulatory limits. This can influence planning and logistics around digestate application. Nevertheless, it would be wrong to say that the livestock manure limit represents a constraint on the promotion of recycled organic fertilisers in agriculture. The directive is based on the very notion of better using the nutrient content of livestock manure while maintaining the close organic link between the livestock and the soil (land-based farming) in consideration of the limited carrying capacity of the soil. The limit on livestock manure therefore promotes natural circularity. By putting a constraint on manure application especially in high livestock density regions, the limit also promotes the redistribution of excess nutrients from such regions where nutrients are a pollutant to regions where nutrients are needed, through processing and transport. Moreover, the limit promotes the sharing of livestock manure between farms at the regional level and the processing of livestock manure in biogas plants. This can facilitate the redistribution of nutrients in the form of digestates within the region. Additional requirements on digestate production, type of fertiliser

[9] This may also be done by the provider of the digestate.

composition or rules for placing the product in the EU market are covered by the Fertilising Products Regulation[10].

The Nitrates Directive and technological developments

The directive allows the Commission to adapt non-essential elements of the directive's annexes to scientific and technical progress through a comitology procedure. An example of this is the recent RENURE amendment[11]. This amendment will allow Member States to authorise the application of certain types of materials derived from manure processing attaining qualities close to chemical fertilisers (see section 4.3 of the report). Such materials may be based on digestates subjected to further processing. In this way, the directive provides flexibility to reflect technical progress and encourages technological innovation and new processing methods. The amendment stopped short of allowing digestates as such above the limit, as the results of the analysis carried out by the JRC in 2020[12] did not provide a robust basis for considering digestates as sufficiently close to chemical fertilisers. Indeed, the RENURE amendment is based on the premise that RENURE materials are fundamentally different from livestock manure and present agronomic and environmental qualities and risks more similar to chemical fertilisers. The amendment therefore lists specific types of processing that are required for materials to be considered as RENURE. Further processes may be considered in the future, based on robust scientific evidence, and added to the annex through another comitology procedure.

Concluding remarks

Biogas production and the application of digestates in agriculture hold significant promise for advancing sustainability and circular economy principles. As biogas facilities continue to expand, the integration of digestates into agricultural systems can help close nutrient cycles, reducing reliance on synthetic fertilizers and minimise waste. However, this approach requires careful management to balance the environmental benefits with potential risks, such as ammonia emissions, nutrient leaching and contamination from harmful substances originating from diverse feedstocks. The Nitrates Directive can affect the use of digestates in agriculture by imposing constraints aimed to protect water quality. One of the limitations established by the directive is the 170 kg N/ha per year limit on nitrogen from livestock manure in NVZ. This restriction directly influences the amount of digestate derived from livestock manure that can be applied to agricultural lands, ensuring that nitrogen levels do not contribute to water pollution. The RENURE amendment will provide flexibility for some materials, subject to further processing, and can be further expanded in the future based on scientific evidence. All in all, the directive does not hinder the adoption of digestate as a fertiliser under environmentally safe conditions. The directive promotes judicious nutrient

[10] Regulation (EU) 2019/1009

[11] Comitology register

[12] Huygens, D., Orveillon, G., Lugato, E., Tavazzi, S., Comero, S., Jones, A., Gawlik, B. and Saveyn, H., Technical proposals for the safe use of processed manure above the threshold established for Nitrate Vulnerable Zones by the Nitrates Directive (91/676/EEC), EUR 30363 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-21539-4, doi:10.2760/373351, JRC121636.

management planning, requiring farmers to calibrate the nitrogen content of digestate applied to soils. While the ND provides a general framework for nutrient management, it also offers large flexibility to Member States. Different national strategies, ranging from strict integral approaches to more flexible manure proportion methods (see above), mean that farmers and land managers must be acutely aware of regional mandates when using digestate. Increased cooperation among stakeholders—farmers, industry experts, policymakers, and researchers—can facilitate the development of best practices, ensuring that digestates contribute positively to both environmental goals and economic viability. These collaborative efforts can facilitate the redistribution and effective use of nutrients, aligning with regional agricultural requirements and promoting resilience of the farming sector.

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