Anaerobic Digestate-Based Fertilizers in Agriculture: Benefits, Limitations, and Future Prospects - A Comprehensive Review

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Keywords: anaerobic digestion, waste, valorization, agriculture, fertilizer
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The use of anaerobic digestion as a sustainable method for treating and processing organic waste has gained significant attention in recent years. Anaerobic digestion produces biogas and nutrient-rich anaerobic digestate, which can be used as a fertilizer in agriculture (figure 1).

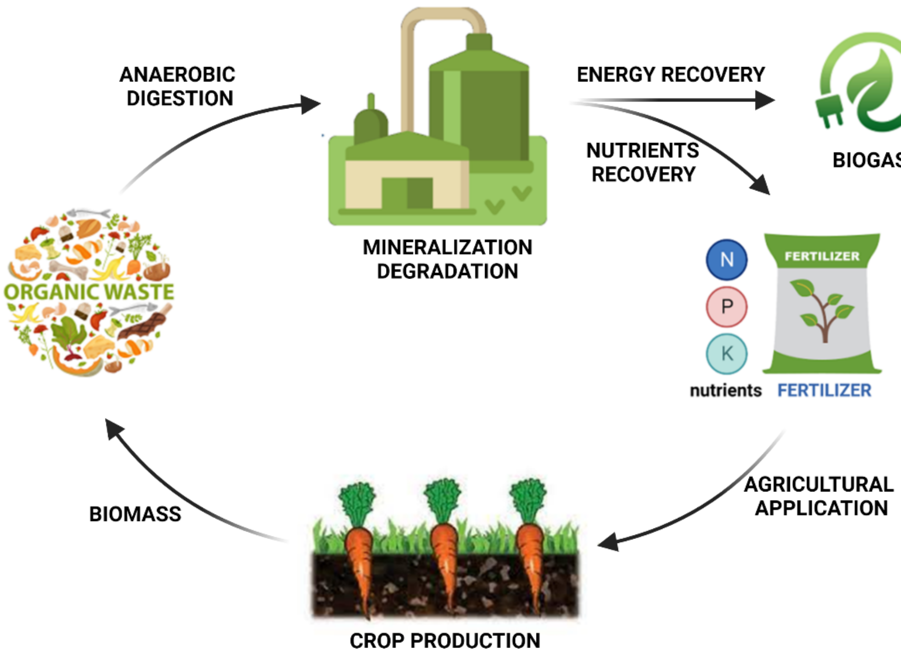

Figure 1. *The closed loop of nutrient flow*

Digestate contains nutrients and an adequate amount of organic carbon. Therefore, it is a valuable fertilizer raw material and is competitive with natural organic fertilizers (manure) and NPK fertilizers. The application of digestate has been shown to increase chlorophyll and carotenoid content and alleviate oxidative stress [1]. Despite its beneficial effects on plants, there are reports of phytotoxic effects of digestate in plant tests [2]. Therefore, treating it and preparing a suitable fertilizer formulation before using it for agricultural purposes is necessary. It seems essential to check the effect of digestate on plants each time and to select the optimal dose for selected plant species.

This comprehensive review examines the benefits, potential, and prospects of anaerobic digestate-based fertilizers in agriculture.

Anaerobic digestate-based fertilizers are becoming an attractive alternative to traditional chemical fertilizers due to their balanced nutrient profile and positive impact on soil health [3]. Anaerobic digestate (AD) contains essential plant nutrients, including nitrogen, phosphorus, potassium, micronutrients, and organic matter, making it an ideal fertilizer for various crops and plants [4]. The organic matter in anaerobic digestate helps improve soil structure, water-holding capacity, and nutrient availability, promoting better root growth and overall plant health [5].

Using anaerobic digestate-based fertilizers has also shown promise in reducing greenhouse gas emissions [6]. The production of biogas during anaerobic digestion can help reduce greenhouse gas emissions by providing a renewable energy source. Additionally, using anaerobic digestate as a fertilizer helps reduce the amount of waste sent to landfills, where it would otherwise generate methane and other greenhouse gases [7].

Despite the benefits, using anaerobic digestate-based fertilizers also has limitations. The nutrient content of anaerobic digestate can vary depending on the feedstock used, the digestion process, and the storage conditions. The cost of production and transportation of anaerobic digestate can be a barrier to its widespread adoption [8].

To overcome these limitations, further research and development are necessary to optimize the production and utilization of AD-based fertilizers. Technological advancements in anaerobic digestion, such as using advanced monitoring systems and developing new feedstocks, e.g., algal biomass, can help improve the process's efficiency and stability [9].

Acknowledgments

This work was financed by European Union's Horizon2020 Research & lnnovation Programme under grant agreement No 696356 and from the Executive Agency for Higher Education, Research, Development and lnnovation Funding - UEFISCDI (Romania), the National Centre for Research and Development - NCBR (Poland), Agenda Estatal de Im/estigación - AEI (Spain), and the Ministry of Agriculture and Forestry- MMM (Finland).

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