Organic wastes as an anaerobic digestion feedstock for batch reactors – A review

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Introduction

Anaerobic digestion (AD) process is applied worldwide in the treatment of various organic wastes, allowing energy production from biogas and organic recovery from digested sludge, in this way contributes to the waste management, to achieve the targets of renewable energies by biogas (Cabrita *et al*., 2016) and to the circular economy by the digested sludge.

In Europe, in 2021 there were 18,843 biogas plants (including landfills) and 1,067 biomethane plants in operation. By 2030, it is estimated that the biogas and biomethane will more than double their production, from 18.4 billion cubic meters (bcm) in 2021 to around 35-45 bcm (EBA, 2022).

Due to the growing demand for biogas and biomethane production, it is extremely important to select the suitable substrate for anaerobic digestion. To achieve this, it is necessary to determine the substrate's physicochemical characteristics and composition, which influence the anaerobic degradability (Daniel *et al*., 2022) which is reflected in the biogas or methane production and the percentage of solids (total solids or volatile solids) that are destroyed.

Usually, the feedstocks for AD can be divided into solids, slurries and liquids giving the moisture content, or in readily degradable to complex wastes, according to degradable fraction. Therefore, the feedstocks can be divided into animal manure, sludge, food waste, energy crops, and other organic wastes.

The present work intends to present and analyse the different feedstocks characterization for AD. To achieve the objective an extensive literature review was performed to collect the potential feedstocks sources (Figure 1) and characterization in terms of solids (total and volatile), organic matter (chemical oxygen demand) and pH were present.

Methodology

To achieve the objective an extensive literature review (scientific articles, thesis, reports and other documents) was performed to collect the potential feedstocks sources (Figure 1) and characterization in terms of solids (total and volatile), organic matter (chemical oxygen demand) and pH were present. In the present work five different classes of feedstocks were considered, according with Table 1.

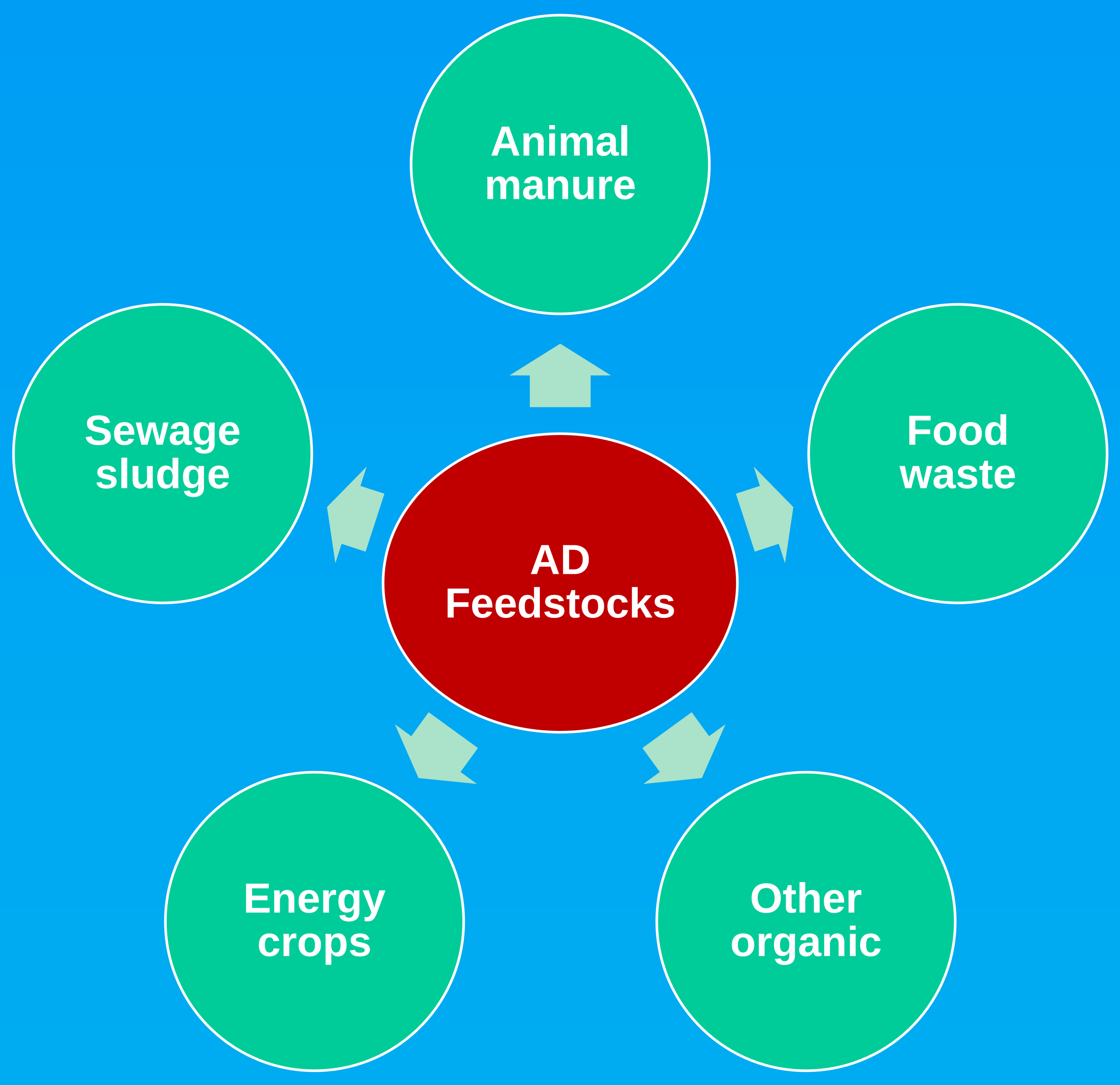

Figure 1: Feedstocks for anaerobic digestion

Table 1: Feedstocks classification

Animal Manure	Sludge	Food Wastes	Energy crops	Other organic wastes
➢ Dairy	➢ Sewage	➢ Household	➢ Maize silage	➢ Fats
➢ Swine	➢ industry	➢ Restaurant	➢ Napier grass	➢ Oils
➢ Beef		➢ Grocery	➢ Energy cane	➢ Grease
➢ Poultry		➢ food production	➢ Switchgrass	➢ Crop residue
			➢ Wheat	➢ winery/brewery waste

Results & Discussion

The feedstocks characterization in terms of total solids (TS) and volatile solids (VS), organic matter – chemical oxygen demand (COD) and pH is presented in Table 2 (Beily *et al.,* 2023; Mlaik *et al.,* 2022; Lisboa *et al.*, 2013; Mioduszewska *et al*., 2020). The TS, VS and COD parameters are presented in different units, which makes it more difficult to compare different feedstocks.

Table 2: Feedstocks characterization

	Animal Manure	Sludge	Food Wastes	Energy crops	Other organic wastes
pH	6.3 - 8.9	5.0 - 7.6	2.9 - 7.2	5.9 - 6.7	3.5 - 7.00
TS	3.8 - 79.9% 47.7 - 938.0 g/kg 4.0 - 73.6 g/L	0.4 - 19.2% 47.3 - 71.2 g/kg 6.5 - 106.1 g/L	0.7 - 95.6% 71.4 - 991.0 g/kg 9.1 - 289 g/L	4.1 - 94% 51.8 - 938.1 g/kg	0.02 - 100%; 265.0 - 505.2 g/kg 1.47 - 331.33 g/L
VS	11.9 - 90.0% 26.1 - 794 g/kg 1.7 - 64.8 g/L	0.7 - 94.7% 40.5 - 54.9 g/kg 3.4 - 60.1 g/L	11 – 100% 51.2 - 988.8 g/kg 9.3 - 275 g/L	25.8 - 95.51% 37.7 - 862 g/kg	5.55 - 99% 228 - 940 g/kg 1.1 - 305.0 g/L
COD	24.6 - 307 g/L 71 - 915 g/kg	9.4 - 228.0 g/L 83.9 g/kg	17.9 - 3581 g/L 90.5 – 2,880.0 g/kg	27.8 – 1,702 g/kg	331 - 1408 g/kg 2.52 - 902 g/L

As can be seen in Table 2, the lowest pH values are those of food waste (2.9) and other organic wastes (3.5) and the highest pH value is from animal manure. Usually, these wastes need pH adjustment by adding reagents (acid or base) or mixing with other feedstocks, in order to achieve the pH value adequate for the microorganisms involved in AD. According to Cecchi *et al*. (2002) de AD process is stable in the pH range of 6.5 to 7.5.

The TS and VS content of the feedstocks vary significantly, from 0.02 to 100% and 0.7 to 100%, respectively, when compared to the database presented by Moretta *et al.* (2022).This fact can probably be explained by the feedstock's variability, but also by the different analytical methods applied in the determination of solids. Also, the COD values are discrepant probably due to the feedstocks solids contents, which influences the choice of analytical method and consequently the results.

Conclusions

The present work shows that AD process continues to be applied worldwide to several feedstocks and mixtures of them with methane production, a renewable energy. The feedstocks characterization can be done with several parameters (TS, VS, COD and pH), which have different value ranges. Therefore, it is important to continue the investigation of new feedstocks and their mixtures for the AD process.

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