retaste

rethink food resources, losses, and waste 2024

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Anaerobic Co-Digestion of Agri-Industrial Residues in Livestock Manure Management For Circular Bioeconomy Enhancement in Alpine Territories

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Abstract

The alpine regions are inclined to tourism and livestock farming but their territory shows some peculiarities, such as sloped fields and roads, remote small-scale agri-food farms with a heterogeneous distribution, and site-specific industrial companies with seasonal residues. In some cases, agri-food residues are sent outside the region or disposed of as wastes, even if they contain a high amount of nutrients that could be reintegrated into agriculture (mainly through co-digestion). The main aim of this study is to put the basis for a mountain-district management model for energy and nutrient exploitation of the organic residue streams deriving from farming and the agri-food sector, thus proposing solutions for local bioeconomy business models at the district level, with new biobased alternatives to replace the conventional synthetic fertilizers. Firstly, an inventory of local organic waste characterization of Trentino region (Italy) was realized, reporting for each stream its quantity, localization, typology, seasonality, actual destination, biomethane potential (BMP), and nutrient content when available from literature (N, P, K). The implementation of the organic waste inventory allowed an estimation of maximum biomethane potential of about $21.1 \cdot 10^6$ Nm3 CH4/year (of which $17.5 \cdot 10^6$ from livestock manure, $2.2 \cdot 10^6$ from non-seasonal agri-food residues, and $1.3 \cdot 10^6$ from seasonal agri-food residues). Moreover, as regards nutrient availability (N and P), selected local agri-food residues (MIX: fruit processing residues, brewery spent grains, exhausted grape marc, and bread residues) could provide a theoretical stock of 208 and 41 tons/year for total nitrogen and total phosphorus, respectively. The integration of these quantities in the circular bioeconomy has the potential for fossil fertilizer substitution and local sustainable recycling of nutrients of, respectively, $12.4\%_N$ (over 1678 $tons_N$/year) and $14.1\%_P$ (over 290 $tons_P$/year) of the total nutrient content in the fertilizers distributed in Trentino (ISTAT, 2022). Secondly, the experimental activity focused on the integration of agri-industrial residues with livestock slurry in anaerobic digestion (AD). The batch tests on their biomethane potential (BMP) were analysed to assess the synergistic effect of different substrates in co-digestion (as in Li et al., 2018), sometimes even negative (from -13% to +30% concerning the weighted sum of a single BMP). The MIX was also analysed. The MIX was tested in a semi-continuous anaerobic test with cow slurry manure in the ratio of 30:70 w/w, respectively, as it is admitted in anaerobic digesters located in agricultural lands. There is a significant increase in biogas production in co-digestion tests but, together with the increase in specific methane potential, there is a higher increase in specific carbon dioxide potential. Thus, innovative techniques to enhance the methanogenic activity and/or carbon capture and utilization (CCU) techniques are advocated in future evaluations to improve the carbon footprint of the whole processing chain.

Keywords: livestock manure, agri-industrial residues, synergistic effect, nutrients recovery, bioeconomy model

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