Environmental consequences of including food waste management in agricultural biogas production

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Abstract
The main objective of this study was to assess and compare, from a life cycle perspective, the environmental performance of two real biogas plants, which include or not the use of food waste as a co-substrate. Food waste showed a beneficial role in biogas production since it is considered as a waste but also it has a high biogas potential. Thus, an improvement of the biogas production system related environmental profile is improved.

Keywords
Anaerobic co-digestion; bioenergy production; environmental credits; organic waste

INTRODUCTION

The effective management of municipal solid waste (MSW) is an important environmental concern (Fernández-Nava et al., 2014). Landfilling of MSW represents the dominant practice in the European Union (European Environment Agency, 2010). Particularly, the disposal of the organic fraction of MSW (OFMSW) in landfills causes environmental burdens associated with greenhouse gases (GHGs) emissions and nutrient-rich leachates. In this framework, the Landfill Directive (EU, 1999) encourages Member States to create national strategies for the progressive reduction of biodegradable MSW landfilling. Following the waste hierarchy defined in 2008 (EU, 2008), the use of waste as a source for energy production is considered one appropriate approach. The main objective of this study was to assess and compare, from a life cycle perspective, the environmental performance of two real biogas plants, including or not the use of food waste as a co-substrate.

MATERIALS AND METEHODS

Life Cycle Assessment (LCA) was used to assess the environmental impacts (ISO 14040, 2006). As mentioned, the goal of this study was to analyse the potential environmental impacts of two agricultural biogas plants, both involving bioenergy production and nutrients recovery. Both plants use maize silage and pig slurry as co-substrates, in different ratios. However, Plant B, different from Plant A, also co-digests the OFMSW and food waste from supermarkets. Both biogas systems include all inputs and outputs flows from raw material acquisition to the production of electricity and the digestate application into land as a fertiliser. All processes included within the system boundaries have been aggregated into four main subsystems, as outlined in **Figure 1.**

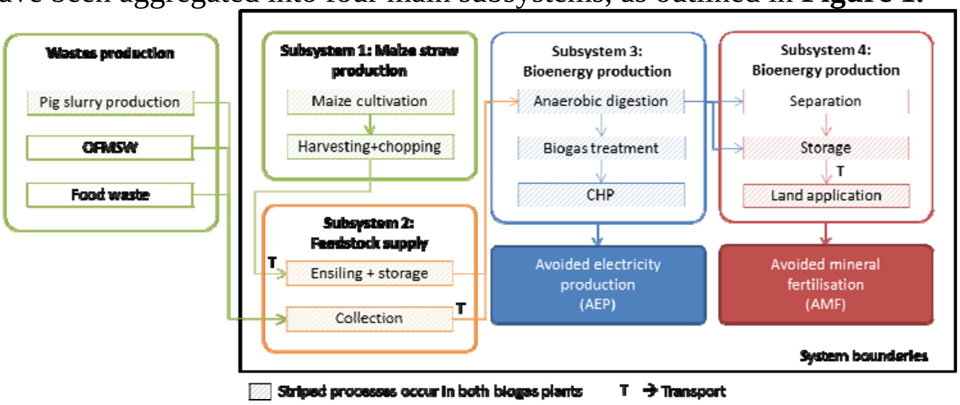

Figure 1. Flowchart and system boundaries of biogas plants under study

RESULTS AND CONCLUSIONS

Life Cycle Impact Assessment was conducted using characterisation factors from ReCiPe Midpoint (H) method (Goedkoop et al., 2009). **Figure 2** shows the comparative environmental results for Plant A and Plant B.

Table 1. Characterisation results of each biogas plant under study

Impact category	Unit	Plant A	Plant B
Climate Change (CC)	kg CO_2 eq	625	-255
Terrestrial Acidification (TA)	kg SO_2 eq	11	13
Freshwater Eutrophication (FE)	kg P eq	-0.63	-0.10
Marine Eutrophication (ME)	kg N eq	-2.76	-1.72
Photochemical Oxidant Formation (POF)	kg NMVOC	3.50	1.39
Fossil Depletion (FD)	kg oil eq	80	-127

The key differences found in CC, POF and FD are related with the type of feedstock used. The potential biogas production of each plant is directly affected by the Anaerobic Biogas Potential (ABP) of feedstock. Maize has a high ABP (650 $m^3 \cdot t_{VS}^{-1}$), but also entails important environmental burdens associated with its production. On the contrary, pig slurry has a low ABP (450 $m^3 \cdot t_{VS}^{-1}$), but ,since it is a waste, it does not involve burdens of its production. Plant B also uses OFMSW and food waste. This food waste has a very high ABP (823 $m^3 \cdot t_{VS}^{-1}$) and it is considered as a waste, so it is favourable from an environmental point of view. The differences in TA, FE and ME are related with the differences in the management of the digestate. Plant A separates the digestate into its liquid and solid fraction. Part of the liquid fraction is conducted to the reactor. Thus, emissions related with digestate storage and application on land are diminished. Plant B applies all the raw digestate produced in the reactor on land, deriving on more emissions of ammonia, phosphate and nitrate that affect TA, FE and ME, respectively.

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