Environmental assessment of bioenergy production through suitable wastewater and waste management

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Abstract
This study aims to analyse the potential environmental impacts of using waste activated sludge from a municipal wastewater treatment plant and the organic fraction of municipal solid waste for anaerobic digestion as a suitable disposal alternative as well as a bioenergy source. The electricity consumption in the system as well as the delivery and disposal of the wastes generated showed up to be the most important contributions to the environmental profile of this waste management system.

Keywords
Biogas yield; digestate management; environmental profile; waste activated sludge

INTRODUCTION

Waste activated sludge (WAS) and the organic fraction of municipal solid waste (OFMSW) represent a large amount of the biodegradable waste generated in Europe (Righi *et al*., 2013). The biological treatment of organic wastes is being promoted as a potential alternative to landfilling (European Commission, 2010). The anaerobic digestion (AD) of wastes has the potential not only to provide a suitable scheme for organic waste management, but also to be a source of bioenergy.

GOAL AND SCOPE DEFINITION

This study aims to evaluate the potential environmental impacts of using WAS and OFMSW for AD as a suitable disposal alternative. Life Cycle Assessment (LCA) methodology was the tool selected for the environmental analysis. An Italian full-scale biogas plant associated with a wastewater treatment plant (WWTP) was inventoried in detail. The functional unit selected for this purpose was 1 tonne of feedstock fed into the anaerobic digester.

System boundaries

The system under study was divided in four main subsystems as indicated in **Figure 1**. In addition, avoided electricity production from the Italian grid was also taken into account. All inputs and outputs flows required in each subsystem were collected and taken into account within the life cycle inventory.

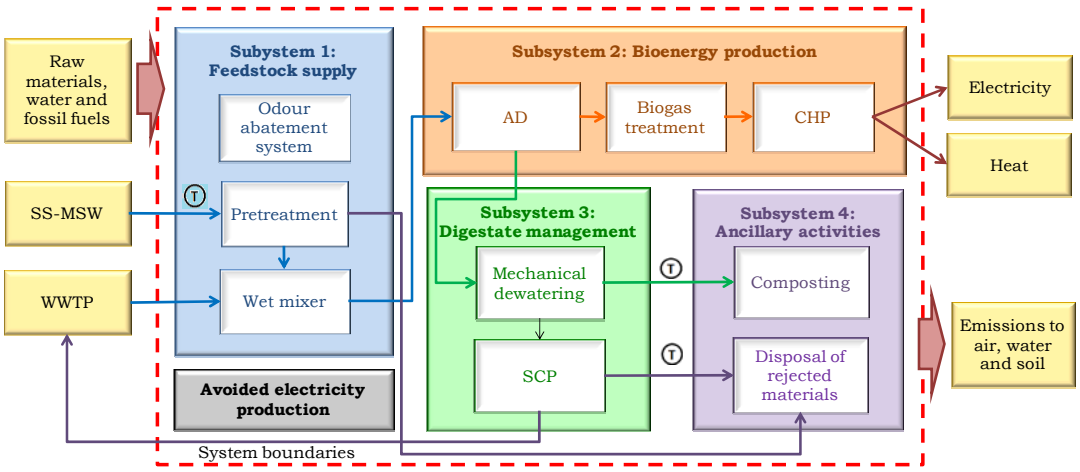

Figure 1.Flowchart and system boundaries of the system under study.

RESULTS

The environmental performance was assessed in terms of climate change (CC), terrestrial acidification (TA), freshwater eutrophication (FE), marine eutrophication (ME) and fossil depletion (FD), using characterization factors reported by the ReCipe Midpoint (Goedkopp *et al*., 2009). **Figure 2** displays the relative contributions from each process within the system under assessment.

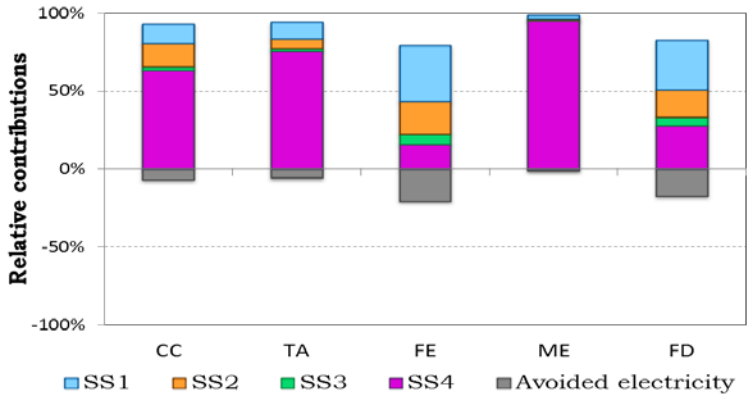

Figure 2. Relative contributions from subsystems involved to each impact category.

In light of the results, CC, TA and ME were mainly affected by the ancillary activities (SS4) (63%, 76% and 95%, respectively) which comprise waste transport and disposal. Concerning CC and TA, the impact was mainly produced by emissions from the composting of the digestate solid fraction, specifically methane and nitrous oxide regarding CC and ammonia in the case of TA. Concerning ME, the disposal in landfill of the rejected materials from SS1 and struvite from SS3 was the major contributor. However, it is important to note that struvite is not reused for local regulatory weaknesses that do not allow the reuse of the material (fertiliser) recovered from wastewater. Concerning FE and FD, the electricity consumption along the system caused most of impacts in these categories, due to the high ratio of non-renewable sources in the Italian electric profile. This electricity is consumed in the pretreatment of the feedstock (SS1) with 36% and 32% of the impacts, respectively and in the digester (SS2) with 21% and 17% of the impacts, respectively. The transport of the digestate to the composting plant (SS4) also had an important influence (16% in FE and 28% in FD). The avoidance of the electricity production from the Italian grid produced positive impacts (negative axis of the graph) in these impact categories. If struvite was used as a fertiliser, the environmental impact of the system would be 2.5-5.5% lower for all impact categories studied, as a result of the avoided management of struvite as a waste and the avoided production of an equivalent amount of phosphate-based fertiliser.

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REFERENCES

European Commission, 2010. Environmental, Economic and Social Impacts of the use of Sewage Sludge on Land. Final Report. Part III: Project Interim Reports.

Goedkopp, M., Heijungs, R., Huijbregts, M., et al. 2009 ReCipe 2008, A Life Cycle Impact Assessment Method which comprises Harmonised Category Indicators at the Midpoint and the Endpoint Level. PRé Consultants, University of Leiden, Radboud University Nijmegen, RIVM, Bilthoven, Amersfoort, Netherlands.

Righi, S., Oliviero, L., Pedrini, M., Buscaroli, A., Della Casa, C. 2013 Life Cycle Assessment of management systems for sewage sludge and food waste: centralized and decentralized approaches. *Journal of Cleaner Production* **44**, 8-17.