Journal of Cleaner Production 158 (2017) 101–108

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

The environmental impacts of alternative food waste treatment technologies in the U.S.

Krista L. Thyberg*, David J. Tonjes

Department of Technology and Society, Stony Brook University, Stony Brook, NY, USA

ARTICLE INFO

Article history:
Received 24 January 2017
Received in revised form
3 April 2017
Accepted 29 April 2017
Available online 2 May 2017

Keywords:
Food waste
Environmental impact
Composting
Anaerobic digestion
Incineration
LCA

ABSTRACT

A Life Cycle Assessment (LCA) was conducted to determine the environmental impacts of several waste treatment scenarios for a suburban New York (U.S.) municipality. The study goal was to determine if separate food waste recovery and management was environmentally sounder than waste-to-energy incineration (the baseline case). Three alternatives, enclosed tunnel composting, enclosed windrow composting, and anaerobic digestion with subsequent enclosed windrow composting of residuals, were examined considering the entire residual waste stream (not just separated food wastes). Impact categories assessed were climate change, environmental eutrophication and acidification, resource depletion, and stratospheric ozone depletion. A normalized, aggregated impact assessment was created to compare the treatments across categories. The anaerobic digestion scenario scored best, followed by the tunnel composting and the baseline waste to energy incineration scenarios, and, last, the enclosed windrow composting scenario. Although it was possible to select an alternative that decreased environmental burdens compared to the business-as-usual case, all modeled scenarios resulted in higher overall environmental burdens than savings, underscoring the need to avoid creating waste to conserve resources and reduce environmental burdens, and ultimately lead to more sustainable waste management practices.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

Food wastage is a complex, interdisciplinary issue which can have profound effects for resource conservation (Thyberg and Tonjes, 2016). Food waste prevention and treatment with technologies that decrease environmental impact are increasingly considered as means to achieve more sustainable global food and waste systems. Policies addressing sustainable food waste management are being proposed and implemented, particularly in the U.S. and Europe. Focus has been placed on food waste due to concerns about the social, environmental, and economic costs of food waste.

Some portion of food waste, even if waste avoidance measures were to be successful, is unavoidable (Schott et al., 2013); reuse opportunities, through redistribution of edible food to humans or animals probably cannot account for the remainder due to perishability and high transport and distribution costs (Buzby et al., 2014), or the excess food may not meet safety or quality requirements (Salhofer et al., 2008). Furthermore, such prevention activities may not appeal to consumers on aesthetic or cultural grounds (Buzby et al., 2011). About 32 million tonnes (MT) of food waste is disposed annually in the U.S., which is 15% of all disposed municipal solid waste (MSW) (Thyberg et al., 2015). Currently waste planners and managers see diversion of this waste from landfills as a means of enhancing stagnant recycling rates, improving environmental conditions associated with waste management, and ultimately contributing to resource conservation and sustainability. Sound analyses of the environmental impacts of specific food waste treatment options would support the development of better and more successful diversion programs.

A life cycle assessment (LCA) is a system assessment tool that quantifies potential environmental exchanges and impacts of system processes. Outputs include indicators which simplify and organize inventory results to make them more understandable (Owens, 1999). Waste system LCAs quantify impacts of interconnected waste management technologies, from generation to final disposal/treatment based on a specified waste composition, and so allow for comparisons between options (Manfredi and Pant,

* Corresponding author.
E-mail addresses: Krista.Thyberg@stonybrook.edu (K.L. Thyberg), David.Tonjes@stonybrook.edu (D.J. Tonjes).

http://dx.doi.org/10.1016/j.jclepro.2017.04.169
0959-6526/© 2017 Elsevier Ltd. All rights reserved.

2013). Previous food waste LCAs usually only model the food waste portion of the waste stream and exclude impacts from other residual wastes (e.g., Lundie and Peters, 2005; Lee et al., 2007; Andersen et al., 2012). An evaluation of the entire system is required to determine which changes are needed for system improvement. This holistic approach also enables a more complete understanding of the overall system as additional factors can be included in the model, such as the effects of differing levels of source separation of the targeted materials. Modeling all residual waste is important when considering combustion technologies, too, since net energy production will be quite small for studies looking only at food waste due to high moisture content (Morris et al., 2014).

Most food waste focused LCA research has been performed in European settings (Laurent et al., 2014), with fewer LCAs performed in the U.S. Table S1 in the Supplementary Materials provides a review of recent food waste focused LCAs, their characteristics, and main findings. Considerable differences between LCA study findings regarding optimal food waste management have been found (Bernstad and Jansen, 2012). However, it is difficult to compare findings from various LCA studies due to differences in modeling approaches, assumptions, and functional units across studies.

The objective of this study was to use LCA to evaluate the environmental impacts of U.S. residential waste disposal to determine if environmental improvement can be achieved by adopting separate food waste recovery and treatment in a suburban municipality (Town of Brookhaven, Long Island, New York). Brookhaven currently disposes of collected wastes using waste-to-energy incineration (WTE) and there is no separation of food waste; this was considered the baseline scenario and alternatives to this baseline were evaluated. The findings were used to determine the conditions under which food waste recovery is beneficial, as well as how LCA analyses can be leveraged to effectively inform decision making focused on sustainable waste management. Emphasis was placed on evaluating the full residual waste stream going to disposal (not only food waste), as impacts and benefits are associated with the entire system of managing wastes, not just the food waste portion. When deciding on approaches for waste system improvements, it is essential to consider the system-wide context rather than just looking at the impacts associated with a single waste fraction. Additionally, determinations of exactly how to aggregate impact categories may affect the interpretation of potential system changes.

Thus, this study is unique because all residual waste was modeled for a suburban U.S. municipality, something previous food waste LCAs have not considered. Four food waste treatments were modeled, including WTE, two types of composting, and anaerobic digestion (AD), to quantify impacts on climate change, eutrophication, acidification, resource depletion, and stratospheric ozone depletion. This assessment indicated conditions where food waste recovery is beneficial and enabled determination of the management scenario with fewest environmental burdens. As mentioned, most prior food waste LCAs only consider food waste in isolation, and so changes in system-wide impacts from alternative food waste treatment are important to examine. Furthermore, no peer-reviewed LCA has been conducted for any of the municipal waste management systems on Long Island to date, although Long Island has been a U.S. pioneer in curbside recyclables collection and long-distance transport of solid waste, banned landfilling altogether in 1990, and sparked policy debates across the U.S. by launching the famous Garbage Barge of 1987 (Tonjes and Swanson, 1994). Ultimately, this investigation can support a discussion regarding effective decision making for sustainable waste management. Food waste is a topic of interest globally, and calls to increase food waste diversion are growing. Therefore, more research is valuable, especially in U.S. settings.

2. Materials and methods

2.1. Scope, functional unit, boundaries and assumptions

The Town of Brookhaven, a suburban New York municipality of 672 km^2 approximately 100 km east of New York City, was used as a case study. The Town provides residential collection services through municipally-negotiated contracts with private carters to 115,315 households (single-, two-, and three-family houses). There is separate collection for paper and container recyclables, yard waste, and residual waste, resulting in 32% diversion from disposal. The residual wastes are collected curbside twice a week by packer trucks, transported to the Town's transfer station for repacking, and then transported by tractor-trailers to the Town of Hempstead WTE plant (Greene et al., 2011).

The functional unit was one tonne of Brookhaven residential residual MSW collected curbside, with a 100 year emissions time frame. The functional unit excludes wastes that have been separated for recycling and yard waste composting, and those deposited at drop off locations, assumed to be identical in all scenarios and thus mutually excluding (Grosso et al., 2012). A consequential LCA approach was used. Scenarios included system expansions to account for changes outside the waste system, such as the substitution of waste derived energy for fossil fuel energy. All environmental emissions upstream from waste collection, including product manufacture, distribution, and use, were omitted (a “zero burden” LCA) (Table S2) (Gentil et al., 2010).

It was assumed that household food waste source separation efficiency was 70%. It is possible that food waste would be commingled with the source separated yard waste currently collected for composting. However, because the functional unit excluded yard waste, any impacts on recovery processes from commingling food and yard wastes were not addressed. The study was performed in accordance with the International Organization for Standardization (ISO) LCA standard 14044 (2006) (ISO, 2006).

2.2. Modeling approach

Four food waste treatment scenarios were modeled using EASETECH (Table 1) (Clavreul et al., 2014). Fig. 1 outlines the modeled processes. The technological systems modeled were available in the EASETECH database, and were adjusted to the U.S. case. AD and food waste composting, although not widespread in the U.S., are potential alternative technologies for food waste because they have been applied broadly and successfully to other organic wastes. There is a proposal to construct an AD facility near the Brookhaven transfer station; AD plants, especially to treat animal wastes, are becoming more common in the U.S., with biogas being an environmentally desirable fuel (Gomez-Brandon and Podmirseg, 2013). Although there are not any food waste composting plants in the general New York metro region, 7% of 3285 U.S. composting facilities accept food scraps (Platt et al., 2014). Therefore AD and composting were modeled as alternatives to WTE (Table 1). Co-processing food wastes at sewage sludge AD plants was not modeled to avoid functional unit complications. The assessment only considered enclosed composting facilities due to odor and vector issues in a densely populated suburban setting. Although landfilling is the primary disposal option for residual waste in the U.S. (USEPA, 2015), it was not modeled because landfilling MSW was banned on Long Island as of 1991 to protect its sole source aquifer system. Over half of residual waste on Long Island is treated by WTE (the remainder is shipped to off-Long Island landfills) (Greene et al., 2011).

Download English Version:

https://daneshyari.com/en/article/5479585

Download Persian Version:

https://daneshyari.com/article/5479585

Daneshyari.com