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Food waste minimization from a life-cycle perspective

A. Bernstad Saraiva Schott*, T. Andersson

Water and Environmental Engineering, Lund University, Kemicentrum, Box 124, 210 00 Lund, Sweden

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ABSTRACT

This article investigates potentials and environmental impacts related to household food waste minimization, based on a case study in Southern Sweden. In the study, the amount of avoidable and unavoidable food waste currently being disposed of by households was assessed through waste composition analyses and the different types of avoidable food waste were classified. Currently, both avoidable and unavoidable food waste is either incinerated or treated through anaerobic digestion. A hypothetical scenario with no generation of avoidable food waste and either anaerobic digestion or incineration of unavoidable food waste was compared to the current situation using the life-cycle assessment method, limited to analysis of global warming potential (GWP). The results from the waste composition analyses indicate that an average of 35% of household food waste is avoidable. Minimization of this waste could result in reduction of greenhouse gas emissions of 800–1400 kg/tonne of avoidable food waste. Thus, a minimization strategy would result in increased avoidance of GWP compared to the current situation. The study clearly shows that although modern alternatives for food waste treatment can result in avoidance of GWP through nutrient and energy recovery, food waste prevention yields far greater benefits for GWP compared to both incineration and anaerobic digestion.

1. Introduction

According to the FAO (2011), the amount of food waste generated in the EU equals 280 kg per year for each EU citizen. Of this, 66% is generated in the production to retail chain and 34% by households. Thus, food waste accounts for a large part of the municipal solid waste generated by households. Previous studies have shown that the fraction of food waste in solid household waste equals 38% in Sweden, (IVL, 2002) 50–70% in Brazil (Mahler et al., 2002), 43% in Turkey (Banar and Özkan, 2008) and 41% in Denmark (Riber and Christensen, 2006). The European Union Waste Framework Directive (WFD) encourages separate collection and recycling of bio-waste and schemes for source-separation of this fraction have been introduced in several European countries. Due to the energy and nutrient content of this waste and the potential for its recovery in the treatment process, previous studies have suggested that treatment of food waste can result in net environmental benefits using anaerobic digestion or composting alternatives (Møller et al., 2009; Boldrin et al., 2009; Smith et al., 2001; Hirai et al., 2000). The WFD also encourages member states to use life-cycle assessment (LCA) to determine the most environmentally beneficial treatment alternative for food waste and other types of bio-waste in the specific local context. The use of LCA as a decision support tool in solid waste management policy-making, as previously proposed by Kirkeby et al. (2006), is therefore likely to increase in the coming years.

The current levels of food waste generation in Europe to a large extent derive from mismanagement of edible food (WRAP, 2008; Salhofer et al., 2008). According to the EU waste hierarchy (European Parliament, 2008), prevention should be the main strategy to decrease the environmental burdens from solid waste in member states. However, the focus on LCA of solid waste management systems is commonly related to comparisons of different treatment alternatives for a specific amount of generated solid waste, while potential environmental benefits from waste minimization commonly not are addressed.

1.1. Definitions

The EU WFD definition of bio-waste, use the term “food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants” (European Parliament, 2008). However, in the present study, as well as in many other academic works in this area, the focus is limited to food waste exclusively. Parfitt et al. (2010) makes a distinction between food losses and food waste, where the former

* Corresponding author.
E-mail address: anna.bernstad@chemeng.lth.se (A. Bernstad Saraiva Schott).

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is related to losses taking place in production, post-harvest and processing stages of the food supply chain and the latter occurs in the retail and final consumption parts of the chain. However, in the present paper, food waste is discussed only in relation to the very last step of the chain – generated by end-consumers.

When discussing food waste prevention, it is important to distinguish between different types of wastes. First, a distinction can be drawn between *avoidable* and *unavoidable* food waste. The need to differentiate avoidable and unavoidable food waste has previously been highlighted (WRAP, 2008; Salhofer et al., 2008). Unavoidable food waste can be defined as waste that occurs in the preparation of food: peels, bones, shells etc., which commonly are not are regarded as edible. Avoidable food waste can be defined as products which could have been eaten and consists of prepared but uneaten food (e.g., cooked pasta), food which was left to go bad (e.g., dry bread or rotten fruits and vegetables) and other food products that were disposed of in edible condition. In some cases, a third category – *possibly avoidable* food waste – has been defined as food waste which in some gastronomic cultures is seen as avoidable, but as unavoidable in others (WRAP, 2009). Some examples are bread crusts and potato peels. In the present study, only the two categories *avoidable* and *unavoidable* food waste are used.

Based on the definitions above, it can be argued that unavoidable food waste is a result of the very nature of the food we consume at home. If this waste had not occurred in the home as a part of the food preparation process, it would have emerged earlier in the food production chain. Sale of unpeeled and peeled carrots can serve as an example of this. In the first case, a household will produce a larger amount of food waste through the peeling of carrots before consumption. In the latter case, the peeling takes place in industrial facilities and increases the production of food waste from such facilities. The elimination of peels prior to retail sale could also increase the need for packaging and thus result in increased resource utilization and environmental impacts. Such impacts are not considered in the present paper. However, this example clearly demonstrates that in order to address the environmental benefits related to food waste prevention, one must focus on minimizing the *avoidable* food waste fraction.

1.2. Aim and scope

The present paper reports the potentials for household food waste prevention based on a case study in southern Sweden. An assessment was also made of environmental impacts related to two different treatment alternatives for food waste, both unavoidable and avoidable, by modeling of direct and upstream and downstream impacts related to treatment of the functional unit through anaerobic digestion on the one hand and incineration on the other.

2. Methodology

2.1. Waste composition analysis method

Three waste composition analyses were performed in a multi-family residential area in Malmö, southern Sweden. In this area, household food waste has been collected separately in paper bags since 2008. All separately collected food waste and 50% of the bins for disposal of residual waste (randomly selected) were analyzed. This approach is described in detail by Dahlén and Lagerkvist (2008). Waste from a total of 486 households was investigated.

The main categories used in the analyses were avoidable and unavoidable food waste. These fractions were divided into a total of eleven sub-fractions, which in some cases were divided even further. Thus a total of 19 fractions were used in the analyses (Table 1). The weight of packaging was included in the categories "unopened packaging" and "opened packaging" in cases where food was disposed of in its original packaging. Thus, packaging was not separated from the content and assumptions were made in relation to the ratio of packaging to food waste.

Table 1
Sub-fractions used in the detailed assessment of avoidable and unavoidable food waste.

Avoidable	Unavoidable
Unopened packaging	Tea and coffee grind
Meat	Peels, shells, cores and trimmings
Other unopened food	Bones, skin, fat
Opened packaging	Other unavoidable
Meat	
Bread	
Dairy products	
Vegetables and fruits	
Other opened food	
Half eaten food	
Vegetables and fruit	
Dairy products	
Prepared food	
With meat	
Without meat	
Non packaged whole vegetables/fruits	
Non packaged whole bread	
Other meat	
Other avoidable food	

The sub-categories used for avoidable food waste can be used to describe the waste both in different types of food as well as to give information of the life stage of the food product when discarded. The groups for different food types used were: *Meat*, *Bread*, *Prepared food*, *Dairy products*, *Fruits* and *vegetables* and *Other*. The life-stage categories used were: *Unopened packaging*, *Opened packaging*, *Half-eaten food* (unprepared left-overs, for example half-eaten apples), *Prepared food* (food which had been cooked/fried etc. before being discarded, for example cooked pasta or fried meat), *Non packaged whole vegetables/fruits* (for example whole, uneaten apples), *Other meat* (unprepared) and *Other avoidable food* (mostly candy, potato chips and popcorn).

2.2. Environmental impact assessment

LCA methodology, as described by Finnveden et al. (2009), was used, using system expansion and based on a consequential approach. The avoidable food waste fraction was classified as 100% preventable while the unavoidable food waste fraction was seen as unpreventable. Waste prevention was evaluated through modeling upstream and direct emissions associated with production of avoided food and packaging material. Alternative treatment of this waste was modeled as direct as well as upstream and downstream impacts related to treatment of the functional unit through anaerobic digestion, composting and incineration. The assessment was limited to emissions of greenhouse gases.

2.3. Function unit and system boundaries

The functional unit was defined as the service of managing one tonne (metric ton) of food waste from Swedish households. However, waste prevention inherently changes the functional unit (Ekvall et al., 2007). Cleary (2010) uses the terms primary and secondary functional units to ensure both a fixed amount of MSW managed in scenario comparisons including waste prevention, as well as identical reference flows of functionally equivalent product services. However, the same author also states that a secondary functional unit is not required to ensure the functional equivalence of product services if addressing services that are deemed