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Carbon footprint of food waste management options in the waste hierarchy – a Swedish case study

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ABSTRACT

Food waste is a problem with economic, environmental and social implications, making it both important and complex. Previous studies have addressed food waste management options at the less prioritised end of the waste hierarchy, but information on more prioritised levels is also needed when selecting the best available waste management options. Investigating the global warming potential of different waste management options offers a limited perspective, but is still important for validating generations from the waste hierarchy in a local context. This study compared the effect on greenhouse gas emissions of different food waste management scenarios representing different levels in the waste hierarchy in the city of Uppsala, Sweden. A life cycle assessment was performed for six waste management scenarios (landfill, incineration, composting, anaerobic digestion, animal feed and donations), using five food products (bananas, grilled chicken, lettuce, beef and bread) as examples when treated as individual waste streams. For all five waste streams, the established waste hierarchy was a useful, but approximate, tool for prioritising the various options, since landfill proved to be the worst option and donation, anaerobic digestion and incineration with energy recovery the best options, for easily handle products, wet products and dry products, respectively, taking into account the GHG emissions. The greatest potential for reducing greenhouse gas emissions was in the bread waste stream, since bread is an energy-rich product with a relatively low carbon footprint, increasing the possibilities for replacing fossil energy carriers. Lettuce, with its high water content, had the least potential to reduce greenhouse gas emissions when the waste management method was changed. Waste valorisation measures should therefore focus on food products with the potential to replace production of goods and services, rather than on food products that are wasted in large quantities or have a high carbon footprint.

1. Introduction

Food wastage is a problem of increasing severity, with rising awareness of the extent of the problem in recent years (FAO, 2011, 2012; 2013). Although food losses are just one of many problems that have to be addressed in creating a sustainable food supply chain (Garnett, 2011), concerns about food waste in Sweden have prompted the Swedish government to set goals to reduce the amount of waste and increase organic treatment of food waste (SEPA, 2013). These efforts comply well with the European Waste Framework Directive (WFD), which ranks waste prevention and management options in order of priority in a waste hierarchy (EC, 2008). The WFD also obliges member states to encourage options that deliver the best overall environmental outcome from a life cycle perspective, even when this differs from the waste hierarchy. However, since the environmental outcome is not defined in the WFD, this goal can be achieved in many ways. Addressing the global warming potential (GWP) alone offers a very limited version of the overall environmental outcome, but is no more or less appropriate than targeting any other environmental impact category.

In the case of food waste, the environmental choice of waste management system from a life cycle perspective follows the hierarchy closely in many cases (Laurent et al., 2013a). However, since each waste management system is dependent on a local context, the waste hierarchy must still be seen as a rough generalisation. An actual investigation of each local context is necessary to fulfil the obligation in the WFD.

Early versions of the waste hierarchy have been part of European policy since the 1970s (EC, 1975). While it has been developed and amended (EC, 2008), it still provides only very general guidelines

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for all waste. Guidelines relating specifically to food waste have therefore been devised. Examples of such systems are the Moerman ladder in the Netherlands (Dutch Ministry of Economic Affairs, Agriculture and Innovation, 2014), the Food Recovery Hierarchy in the United States (USEPA, 2014), and the Food Waste Pyramid in the United Kingdom (Feeding the 5000, 2014). All these systems prioritise prevention, since the waste management options include downcycling and loss of the intended product. Despite the order of priority in the waste hierarchy, only a few studies measure waste prevention in the context of waste management (Laurent et al., 2013a). This omission may be due to the methodical difficulties of measuring something that is not there (Zorpas and Lasaridi, 2013) or, as discussed by van Ewijk and Stegemann (2015), to prevention being fundamentally different from waste management.

Priority is also given to donations to people in need, although this is limited by the fact that food waste can only be donated to charity if it is food surplus still fit for human consumption (Papargyropoulou et al., 2014). Since the food hygiene or biosecurity requirements increase the higher the level in the waste hierarchy, there is a decreasing likelihood that the whole waste flow will be suitable for the same type of waste management. This creates a need for more complex systems where a food waste flow is developed and used for higher priority waste treatments, while the rest is treated with a lower priority, more general method (Vandermeersch et al., 2014). To analyse the potential of subdividing the food waste stream, instead of treating it in its entirety, an approach with individual waste streams can be used (Vandermeersch et al., 2014).

Most previous studies on waste management methods for food waste, or organic waste including food waste, describe and sometimes compare landfill, incineration, composting and anaerobic digestion (Bernstad and la Cour Jansen, 2012; Laurent et al., 2013a, 2013b). However all these options are found in the less prioritised part of the waste hierarchy. Some studies also include animal feed in the comparison (e.g. Lee et al., 2007; Menikpura et al., 2013; Vandermeersch et al., 2014), but none has included comparisons with the highest levels in the food waste hierarchy, such as donation and prevention. However, some studies describe the environmental benefits of preventing food waste. For example, Gentil et al. (2011) concluded that there could be a 20% reduction in a food waste stream, but did not specify how this reduction could be achieved or the cost of doing so. Williams and Wikström (2011) and Williams et al. (2008) investigated whether waste reduction can justify increased use of packaging material and found that it could do so for resource-consuming products such as cheese and beef. However, those studies did not specify how large the potential reduction could be if the packaging was redesigned. Another prevention study, by Salhofer et al. (2008), regarded prevention as being equal to donation, but did not quantify the actual potential in this measure. Moreover, Schneider (2013) valued donated food by its emissions during production, instead of the produce that could be replaced. The lack of studies quantifying higher levels of the waste hierarchy with a method comparable to the lower levels makes it difficult to evaluate the actual environmental benefits of donations and prevention in relation to other waste management options. Without such extended analysis, the life cycle perspective described in the WFD will not actually be considered when selecting waste management options.

Among the large number of articles and reports reviewed by Laurent et al. (2013a; 2013b), a pattern emerged in studies comparing different waste management alternatives. The least favourable option was landfill, followed by composting and thermal treatment, and the most favourable was anaerobic digestion. However, not all studies fitted this pattern. Therefore Laurent et al. (2013a) concluded that local infrastructure is essential for the outcome, making it more difficult to generalise results.

In the local context of Uppsala, Sweden, supermarkets are not included in the municipal waste monopoly. This means that they are free to use any contractor they wish to handle their waste. According to Eriksson (2012) and Nilsson (2012), this means composting at the local composting facility. Swedish supermarket food waste treatment favours the existing local infrastructure, which often includes an incineration plant since this is the most common waste treatment method in Sweden (SEPA, 2012a, 2012b). This is despite the national environmental goal of having 50% of wasted food from supermarkets, households, canteens and restaurants biologically treated, with recovery of plant nutrients, by 2018 (SEPA, 2012a). The environmental goals also state that food waste in the whole Swedish food supply chain should be reduced by 20% between 2010 and 2020 (SEPA, 2013). For supermarkets to achieve these environmental goals, there is a need for a change in waste management methods. The question is what method to choose and what environmental benefits could be achieved by different waste management alternatives. The objective of this study was therefore to compare the outcome, with regard to greenhouse gas emissions, of different food waste management scenarios available to supermarkets in Uppsala. The overall aim was to provide more detailed knowledge about the quantity of emissions avoided when applying a more prioritised step in the waste hierarchy for the management of food waste.

2. Materials and methods

The life cycle assessment (LCA) method (ISO, 2006a, 2006b) was used to calculate the global warming potential (GWP) associated with different waste management scenarios applied to five different types of food. The functional unit was the removal of 1 kg of food waste (including packaging) from the supermarket.

2.1. Study area

Specific data for different waste management scenarios likely to be used to handle food waste from supermarkets in the municipality of Uppsala were used in the study. Uppsala was selected partly because detailed waste data, which are normally difficult to collect, were already available from previous projects, and partly because the infrastructure for all scenarios (landfill, composting, incineration, anaerobic digestion, animal feed and donations) already exists and could be used to collect site-specific data. Several of the waste management facilities included have also been investigated in previous studies and thus site-specific data for those were available (*cf.* Björklund, 1998; Nilsson, 2012).

The basic assumption in each scenario was that a supermarket chain used a waste management method for all four of its branches located in one city. Two of these branches were investigated by Eriksson et al. (2012, 2014) as regards routines, mass of waste and composition of the waste: a large supermarket in a retail park on the outskirts of the city with other shops in the same building, and a smaller supermarket in a more central residential area. The remaining two supermarkets were assumed to be one out-of-town retail park type and one central residential area type. Calculations on transport-related emissions were based on the distance to each of the four supermarkets, and more waste was assumed to be located in the two further from the city centre.

2.2. Properties of the food products investigated

Since food waste consists of a mixture of foods with a wide variety of properties and characteristics, it is difficult to consider