An evaluation of introducing the OBEO caddy into the food waste disposal system in Ireland

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ABSTRACT

The objective of this study was to evaluate whether introducing the OBEO caddy to the home organic food waste disposal system would result in a lower environmental footprint than if the food waste was sent to landfill. A streamlined life cycle assessment (LCA) was carried out and the environmental impacts were quantified in terms of primary energy consumption (PEC), global warming potential (GWP), acidification (EP) and eutrophication (EP) potential. It was found that the OBEO caddy has the potential to greatly reduce the environmental and resource consumption impact of organic food waste and had a positive effect for PEC, GWP and EP. A negative effect for AP was found. Fill rate, and product design to achieve maximum fill rate need further attention and comparisons with plastic caddy's and recycled paper bags need to be undertaken to complete the evaluation of the OBEO caddy.

Keywords: LCA, Food Waste, Composting, disposal caddy

1. Introduction

Food waste is a global issue with an estimated one third of all food produced being wasted (UNRIC, 2014). In Ireland, a limited amount of food waste is captured in brown bins, which are sent for recovery in compost facilities. The Irish product design company OBEO has created an innovative, simple and fully compostable disposal caddy to facilitate food waste disposal in the home by making it clean and easy to undertake. OBEO's market research identified that by 2016 population agglomerations of more than 500 households would have access to a brown bin, which equates to a potential market of 1.2 million households in Ireland. The existing practice of landfilling food waste is no longer accepted as a suitable management option. The aim of this study was to estimate whether introducing the OBEO caddy to the home waste disposal system would result in a lower environmental impact than if the food waste was sent to landfill.

Figure 1. OBEO compostable Caddy

2. Methods

The streamlined environmental footprint and comparative analysis were performed in adherence to LCA methodology, standardised by ISO 14040 and 14044 (ISO, 2006a, b). LCA methodology has been used to evaluate and compare a large number of waste management technologies (Blengini, 2009; Kong et al. 2012; Martinez – Blanco et al. 2009). The LCA methodology consists of four phases: (1) goal and scope definition; (2) inventory analysis; (3) impact assessment; (4) interpretation, which were followed for this study.

2.1. System boundary and functional unit

The study is a comparative LCA, evaluating food waste disposal in landfill and in-vessel composting facility. This study did not consider the environmental impact of waste generation and its subsequent use as a resource. The upstream boundary was set at the waste collection stage. This is the approach followed in the majority of waste management studies, known as the "zero burden assumption" (Ekvall et al., 2007) and is applied when the waste coming into two comparative systems is regarded as being the same for both systems and thus can be omitted from calculations, or assumed to have zero burden (Finnveden, 1999). This method did not allow for the quantification of the food waste impact, but as this was a streamlined LCA it allowed the manufacturer to get a clear understanding of the potential impact their product may have.

The system under study consisted of the OBEO caddy manufacture and transportation to point of use; waste transportation from household to composting facility; treatment of waste in composting facility, the reference system was the collection of food waste and transport to landfill. The functional unit of the study was the disposal of 1000 kg of food waste.

2.2. In-vessel composting system

Once the food waste has been placed into the OBEO caddy it is consigned to the brown (organic waste) bin and sent for further treatment. The treatment process that was modelled in this study was in-vessel composting as it is the most suitable technology and is commonly used in Ireland. Full details of the composting process are outlined in Table 3. The data used in this study were taken from a number of LCAs carried out for Irish and European in-vessel composting processes. The composting plant modelled in had the capacity to process 15,000 t yr^{-1} of organic food waste.

2.3. Life cycle Inventory

The OBEO caddy consists of a paper bag which is housed in a cardboard (Kraftpack) case. Table 1 presents the inventory for the caddy manufacture and transportation.

Table 1: Characteristics of the food bag and kraftpak and distribution distances for the OBEO caddy.

Characteristics	**Food bag**	**Kraftpack**
Food bag mass (for one bag)	0.019 kg	-
Dimensions	200 x 115 x 390 mm = 0.00897 m^3	220 x 736 mm = 0.162 m^2
Volume/Mass	0.00897 m^3 = 8.97 litres Manufacturers assume 8 litres	0.162 m^2 x 0.283 kg/m^2 = 0.0458 kg
Manufacturer	Segezha Packaging	Kapstone paper
Location of manufacture	Southern Sweden	Illinois, USA
Delivery mode to Ireland	Ship & truck	Ship & truck
Distance	1637 km	5909 km

The OBEO caddy is held together with a glue and ink is used to place the logo on the Kraftpack. These items were not included in the analysis. Site specific data for the manufacture were not available, thus industry average data from the eco-invent and ELCD databases were used. It was assumed that these data were representative of the current, European produced paper and cardboard. Market research by OBEO defined typical food waste data (Table 2) used to design the OBEO caddy. Sensitivity analysis of the fill rate for the OBEO caddy was undertaken to evaluate the impact if not being completely full on environmental performance.

Table 2: Food waste data for the design of the OBEO caddy

Characteristic	Value
Food waste density range	343-515 kg/m^3
Food waste density average	429 kg/m^3
Mass of waste per OBEO	Maximum 2.3kg

It was assumed that the food waste for the reference system would be collected in a plastic bag at a rate of 10kg per bag. Table 3 presents the inventory data for the plastic bag.

Table 3: Characteristics of the plastic bag and distribution distances for the reference flow.

Characteristics	Plastic bag
Food bag mass (for one bag)	Assumed 10 kg
Volume/Mass	50 L
Location of manufacture	Assumed Illinois, USA
Delivery mode to Ireland	Ship & truck
Distance	5909 km

The compost facility data used for the study are presented in Table 4, whilst the data for Landfill is presented in Table 5.

Table 4: Compost inventory data used for the streamlined LCA.

Type of flow	Units	Quantity	Reference
Input			
Diesel	kg	4.73	Martínez-Blanco et al. (2009)
Electricity	KWh	50.5	Martínez-Blanco et al. (2009)
Food Waste	Tonne	1	Martínez-Blanco et al. (2009); Blengini (2008); White (2012).
Output			
Compost	Tonne	0.2	Martínez-Blanco et al. (2009); Blengini (2008); White (2012)
CO_2	kg	156	Blengini, 2008
Ammonia	kg	0.6	Blengini, 2008
Methane	kg	0.034	Martínez-Blanco et al. (2009)
VOC	kg	1.210	Martínez-Blanco et al. (2009)
Nitrous Oxide	kg	0.092	Martínez-Blanco et al. (2009)

The landfill was modeled using the process "landfill of biodegradable waste" from the ELCD database. Table 5 presents the typical flows for landfill.

Table 5: Landfill inventory data used for the streamlined LCA (ELCD, 2014).

Type of flow	Units	Quantity
Input		
Electricity	KWh	222
Food Waste	Tonne	1
Plastic Bag	g	300
Output		
CO_2	kg	62.6
Methane	kg	27.8
Nitrous Oxide	kg	0.00291

2.4. Life Cycle Impact Assessment

Four impacts (Table 6) were assessed, three followed the impact methodology CML 2001 (GWP, EP & AP).

Table 6: Impact Category, indicator and unit

Impact Category	Indicator	Unit
Global warming potential (Specifically - CO_2, N_2O, CH_4)	GWP_{100}	Kg CO_2 eq
Eutrophication potential	EP	Kg PO_4 eq
Acidification potential	AP	Kg SO_2 eq
Primary energy consumption	Energy Consumed	MJ

3. Results and Discussion

The results for the OBEO (Table 7) and landfill (Table 8) scenarios indicated that the OBEO caddy could lead to reduced PEC, GWP and EP, but increased AP (Figure 2).

Table 7: Impacts at composting per 1000 kg organic food waste if the OBEO caddy encouraged targeted disposal

	PEC (MJ)	GWP (kg CO_2e)	AP (kg SO_2e)	EP (kg PO_4e)
OBEO production	5.64	77	0.073	0.011
OBEO transport	0.53	3.5	0.0045	0.057
Waste transport	1.83	5.6	0.025	0.006
Composting process	700	150	35	0.22
Total	708	236	35.1	0.29

Table 8: Impact at landfill for 1000 kg of organic food waste

	PEC (MJ)	GWP (kg CO_2e)	AP (kg SO_2e)	EP (kg PO_4e)
Plastic Bag	4.6	5.0	0.013	0.001823
Waste Transport	52	4.0	0.019	0.0046
Landfill process	800	434	0.303	1.77
Total	856.6	443	0.335	1.776

Energy consumption might be reduced by 148 MJ for every tonne of waste composted rather than landfilled. There is approximately 200,000 tonnes of food waste generated in Ireland annually. If employing the OBEO caddy encouraged composting, this could result in a reduction of 29.6 million MJ of electricity consumption per year which is approximately 0.03% of Ireland's annual energy consumption. Reduction in GWP was calculated at 207 kg CO_2e ton^{-1} when using the OBEO caddy. This was mainly due to the amount of methane that is emitted during landfilling and the CO_2e associated with energy supply. Employing the OBEO caddy resulted in a potential increase in AP of 34.8 kg SO_2e ton^{-1} due to the composting process generating more documented acidifying emissions than the landfill process. It is worth noting that if this study was expanded to a full LCA then the result may be different because post-composting processes and more detail of landfill would be included in the full system model. A significant reduction in EP was observed with the introduction of the OBEO caddy and subsequent composting.

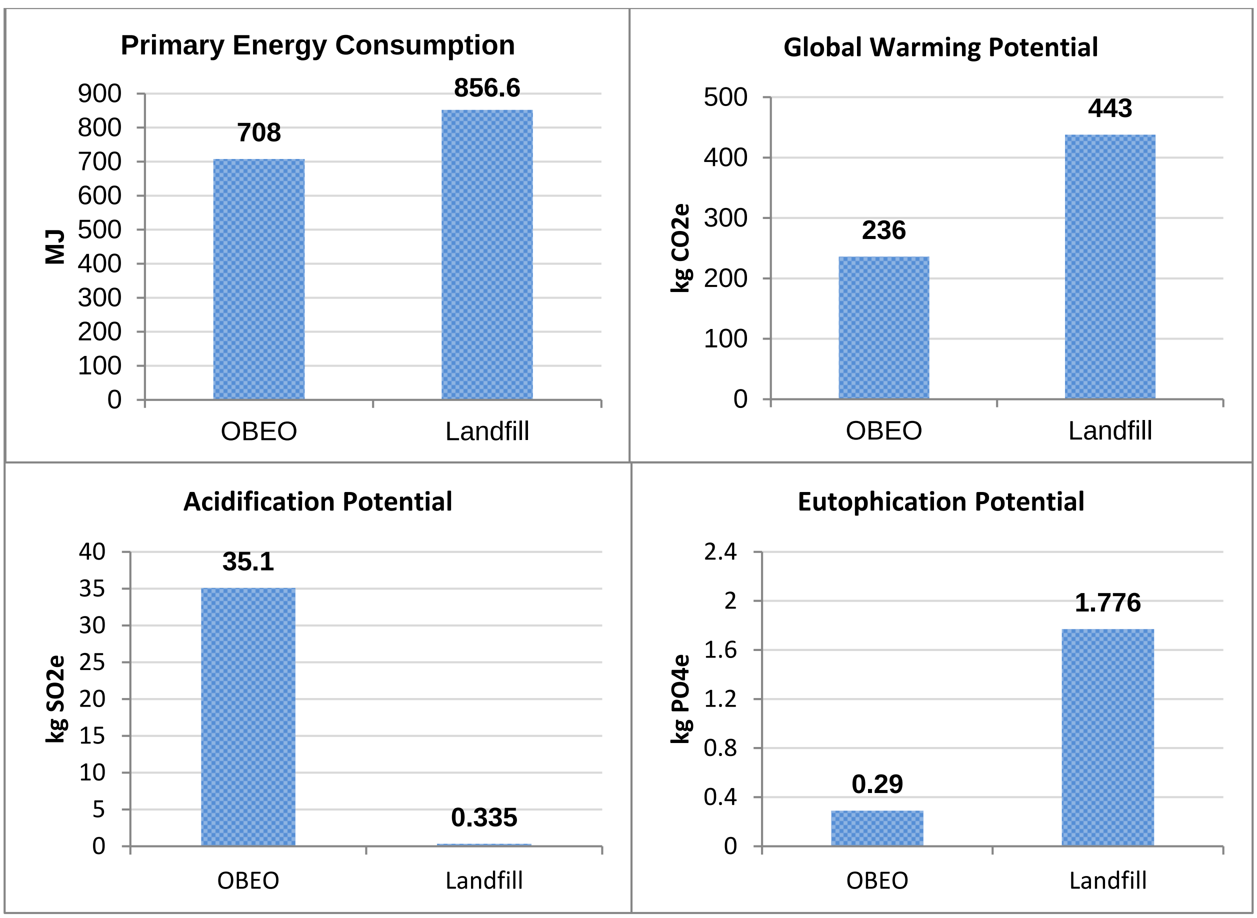

Figure 2. Comparison of the impacts for one tonne of waste composted with the OBEO caddy or landfilled

As this study was limited to a streamlined LCA, the main assumption tested was fill rate. It was assumed that the OBEO caddy would be filled to its maximum with a standard composition food waste (Table 2) when calculating the environmental impacts. The sensitivity analysis examined a 50% and 25% file rate. Reducing fill rate had a very small impact on PEC, AP and EP (data not shown), but there was a large impact on GWP (Figure 3). A 50% reduction infill rate caused a 74% increase in GWP. For 1 kg of waste to be captured approximately 0.4 OBEO caddies have to be produced and used at 100% fill rate. If the fill rate was 50% 0.8 OBEO caddies are needed and at 25%, 1.6 OBEO caddys. At a 25% fill rate the OBEO caddy, while encouraging composting would perhaps result in greater GWP because of the environmental impact of the manufacture and distribution stages in the product life cycle. Therefore to make sure the lowest GWP is realised, the design of the OBEO caddy must facilitate a high rate of food waste capturing, i.e. if an OBEO has a one day life span then its size should reflect the average amount of food waste disposed in one day. The sensitivity analysis suggested that consumers need to maximise use of the caddy to achieve optimum GWP benefit from composting using this system.

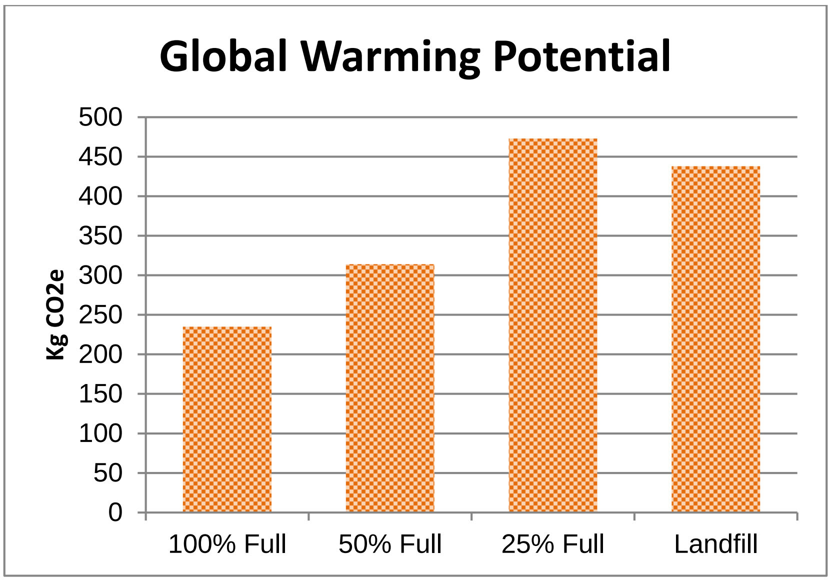

Figure 3. Sensitivity analysis of OBEO caddy to fill rate for GWP impact

As this was a streamlined LCA there was a limited comparison made between using the OBEO caddy to encourage composting and landfill. In reality there are at least two other approaches to food waste capture for composting that might be considered. Firstly the household simply captures food waste in recycled paper bags. As these are the most common bags for carrying shopping in Ireland due to the levy on plastic bags, it is a possible alternative. Secondly, the household captures food waste in a plastic caddy that is reused over and over. This latter alternative could also be lined with recycled plastic bags. It is clear from the design process of the OBEO caddy that simply using paper bags alone will not work well with food waste, which tends to have a high water content and thus paper shopping bags tend not to support wet food waste for transport to the recycling bin. While such an approach is likely to have less impact than the OBEO caddy if a zero burden assumption is used and a high fill rate, it is unlikely to encourage food waste recycling because of the mess and unreliability. This was the very reason for designing OBEO caddy in the first place. The use of plastic caddies is perhaps a serious competitor. In this case the life cycle burden will be diluted over many reuses of the caddy, but a cleaning impact (water use and EP may be important here) will arise. These alternative scenarios, and consumer behavior data on the relative encouragement that each scenario gives to separating food waste for composting need further research.

4. Conclusion

This study identified that the OBEO caddy has the potential to greatly reduce the environmental and resource consumption impact of organic food waste. The OBEO caddy has a positive effect for PEC, GWP and EP impacts but has a negative effect for AP impact, but this may be an artefact of the streamlined LCA. It was identified that fill rate, and product design to achieve maximum fill rate needs to be a focus of attention. To fully assess the value of OBEO from an environmental perspective a more complete LCA study should be undertaken.

It must be noted that the OBEO caddy by itself does not reduce the environmental impact, this only occurs when the food waste is diverted away from landfill and is composted. Thus, if the OBEO caddy was employed to collect food waste which was subsequently landfilled – there would be no environmental benefit, in fact there would be an increase due to its use.

An important outcome of this work is that if by using the OBEO caddy we can encourage more people to separate their food waste which would subsequently be composted in Ireland, then it should of course be used. For this study the important aspect of the lifecycle analysis is the waste treatment process, for Ireland composting or landfill. The OBEO caddy merely facilitates the transportation of the food waste.

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