Journal of Cleaner Production 83 (2014) 70–79

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

Life cycle assessment of alternative bedpans – a case of comparing disposable and reusable devices

Birgitte Lilholt Sørensen*, Henrik Wenzel [1]

Department of Chemical Engineering, Biotechnology and Environmental Technology, University of Southern Denmark, Campusvej 55, 5230 Odense M, Denmark

ARTICLE INFO

Article history:
Received 23 July 2013
Received in revised form
13 April 2014
Accepted 13 July 2014
Available online 31 July 2014

Keywords:
Consequential life cycle assessment
Recylable
Disposable
Reusable
Moulded cardboard
PE

ABSTRACT

Comparing environmental impacts of reusable versus disposable equipment most often confirms the intrinsic assumptions of the "Waste Hierarchy" that product reuse is environmentally preferable to disposal. The present study on hospital bedpans contributes to this line of LCA comparisons. It analyzes the influence of the decisive factors in a comparison of four alternative bedpans using LCA. In contradiction to the general guidelines of the "Waste Hierarchy", it finds that disposable bedpans are environmentally preferable to the reusable ones. This study determines three decisive factors in the environmental comparison, which may change the priority. The first factor is the use of energy for preparation for reuse. In this study washing of the reusable bedpans is a dominating contributor to environmental impacts from the reusable bedpans system. The study confirms that an energy use for recovery in the range of 0.1–0.15 MJ/kg plastic is a probable tipping point. The second factor is the benefit from an environmentally better fate of the organic excreta when using disposable bedpans. The disposable bedpans are taken to energy recovery in waste incineration instead of wastewater treatment. Overall, the disposable bedpans, therefore, perform better environmentally despite the fact that they require new production of bedpans at every use. Finally, the third factor is the influence of a change of functionality on the adjoining systems related to the product. In this study a change of workflow can imply significant savings on other materials flows in the system.

1. Introduction

Following the so-called "Waste Hierarchy" (Council Directive (EC) 2008/98), product reuse is environmentally preferable to material recovery, which is in turn preferable to energy recovery. Special features of the product or system in question may, however, under specific circumstances imply a change in these perceived environmental preferences, and according to the Council Directive (EC) 2008/98, such cases may be documented using Life Cycle Thinking or Life Cycle Assessment, LCA.

A situation, in which the environmental preferences of the "Waste Hierarchy" (Council Directive (EC) 2008/98) may change, is thus:

- If a pre-treatment before reuse or material recovery is needed (e.g. a washing), and if this pre-treatment implies large environmental burdens compared to the rest of the system
- If such a pre-treatment (e.g. washing) implies the shift of pathway of an adjoining flow (i.e. the contained contamination of the product/material), and if this, then, dominates the environmental implications.

Many examples of using LCA to compare waste management options and document environmental preferences are found in the literature. In many cases, the general recommendations on reuse, material recovery and energy recovery are confirmed. This was the case for e.g. Ross and Evans (2003) comparing the reuse versus disposal of plastic-based packaging systems for refrigerators. The plastic packaging is to protect the refrigerators during transport from production to customer. Also Lighthart and Ansems (2007) made such comparisons of reuse versus disposal in a very comprehensive study of cups for drinking, and Unger (2013) made comparative LCA on reusable versus disposable dental burs. Both of these studies are comparing reusable versus disposable versions of

* Corresponding author. Tel.: +45 24984112.
E-mail addresses: bls@kbm.sdu.dk (B.L. Sørensen), henrik.wenzel@kbm.sdu.dk (H. Wenzel).
[1] Tel.: +45 27787374.

http://dx.doi.org/10.1016/j.jclepro.2014.07.022
0959-6526/

different equipment, where the reusable version has to be washed in order to be reused. In spite of this demand for washing, the environmental preferences in both studies were found to be reuse.

An example of a study involving the aforementioned shift in the pathway of an adjoining flow is found in Willum et al., 2005. This study is a review of LCAs comparing alternative waste management pathways of plastic waste streams. The conclusion from this large review study is that in cases where washing/cleaning is needed for plastic waste products; incineration may be environmentally preferable to recycling. Two reasons were found to explain this: The first reason is the need for hot water for washing and the second reason is the change in pathway of the organic contaminants, i.e. that the heat value of the contaminants is partly recovered when incinerating them, whereas energy is needed to remove contaminants from municipal wastewater if the plastic is washed for recycling.

A specific example of this, which is also referred in Willum et al., 2005, is disposal of food packaging, like bottles, cans, jars, etc. Such packaging can contain food residues, and preparing the packaging for reuse or material recovery, i.e. washing is then called for. An example can be a mayonnaise plastic bottle. On disposal (in Denmark), this bottle together with the remaining contents of mayonnaise would enter waste incineration with heat recovery and electricity generation. Preparing it for material recovery could imply hot washing. The mayonnaise content would then go to wastewater treatment, where electricity would be used to remove it from the wastewater, and the waste incineration plant would be deprived of the same mayonnaise for energy recovery. All in all, therefore, material recovery of the mayonnaise bottle compared to energy recovery would *lose* environmentally on 1) the hot water for washing, 2) the electricity for wastewater treatment, and 3) the lost energy recovery from waste incineration of the mayonnaise, whereas it would *win* on the recovered plastic material and, thereby avoid virgin material production. In quantifying this tradeoff under average Danish conditions in 2002, Frees (2002) found that the breakeven between waste incineration and material recovery of plastic food packaging was a contamination degree of around 0.7–1.5 kg COD/kg plastic, above which waste incineration was environmentally attractive to material recovery.

Such key figures of breakeven, of course, depend very much on the particular product, the pre-treatment for preparing it for reuse, and the waste, wastewater and energy system infrastructure within the country.

Grimmond and Reiner (2012) is an example of an LCA study on hospital equipment, like in the present study. They investigate the carbon footprint of disposable versus reusable containers for sharp devices at hospitals and conclude reuse to be better. They find the greenhouse gas emissions to be significantly lower for the reusable containers. The contributions to greenhouse gas emissions were found to be mainly from material production and transport of the disposable containers. Washing was a significant contributor for the reusable containers; however, the greenhouse gas emission from the disposable containers was found to be 4–5 times bigger in total than from the reusable ones.

The Environment Agency in the United Kingdom (UK) (Environment Agency 2005, 2008) has made a thorough investigation of the use of disposable nappies and reusable nappies. It contained a survey with 2101 records on how children are using reusable and disposable nappies, and it found that greenhouse gas emissions were within the same range for the two types of nappies. Further, it found that the impacts from the reusable nappies are highly dependent on the way they are laundered. Thus, the greenhouse gas emission increases up to 73 percent when increasing washing temperature from 60 °C to 90 °C and tumble drying the nappies instead of passive air drying. This illustrates how the conditions related to the preparation for reuse can change the conclusion. Disposable nappies become preferable when the reusable nappies are laundered at a high temperature and tumble dried. The UK waste management infrastructure at the time of the study implied landfilling of disposable nappies, which differs from many other countries in which incineration with energy recovery would be the case. The existence of waste incineration with energy recovery would significantly favour disposable nappies further.

These studies underline that the environmental preference between disposable and reusable equipment is not necessarily a clear case, but it depends on both the concrete details in the foreground system, e.g. a washing before reuse, and the contextual conditions in the background system, e.g. the waste management infrastructure.

The present study on bedpans contributes to this line of LCA comparisons between reusable and disposable devices. It analyses the influence of the decisive factors in comparison of alternative bedpans for use in Danish hospitals. The study includes traditional multiple use bedpans which need to be cleaned and disinfected before use. The waste from washing, defecation and urination in these traditional reusable bedpans ends up in wastewater and has to be handled in wastewater treatment. The alternative types are disposable bedpans, where the organic waste from defecation and urination goes to waste incineration, within which heat is recovered and electricity is generated.

2. Methodology

The LCA presented in this study was performed using consequential LCA (cf. e.g. Ekvall and Weidema (2004)). The impact assessment was carried out using the Danish EDIP method (Wenzel et al., 1997) updated with later impact assessment methodology development (Hauschild and Potting, 2005; Laurent et al., 2011) supplemented by other impact assessment methodology for sensitivity analysis, see later section. The modelling was done in LCA software Simapro 7.3.2.

2.1. Goal and scope

The goal of this study is to provide decision makers with information and guidelines on environmental aspects of single use versus multiple use bedpans in the health and care sector. And secondly it is the aim to extract the general perspectives and lessons to be learnt from this case study. The objectives are met by performing an LCA and comparing four different types of bedpans. Bedpans are used when patients are not able to leave their beds for toilet visits.

In this study, the stainless steel bedpan is chosen as a reference, and the consequence of choosing an alternative type of bedpan is modelled. The environmental impacts of the bedpans are modelled as impacts that are *induced* by using the bedpan in question as well as impacts that are reduced or *avoided* when using the bedpan.

The induced impacts include the impacts from production of raw materials and the bedpans themselves, the electricity and heat used for running of disinfection, and disposal of both the bedpan and its content for either wastewater treatment or waste incineration. The avoided effects include the reduction of the environmental effects from any recovered materials (on recycling) or energy by their substitution of other materials and energy supplies. See the process flow diagrams in Figs. 1 and 2 for a more elaborated presentation of the bedpan systems.

2.2. Functional unit

All calculations, results, and assessments are normalized to the functional unit. The functional unit is in this project chosen to be: use of one bedpan once for urinating and defecating while being