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Source segregation of food waste in office areas: Factors affecting waste generation rates and quality

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ABSTRACT

Existing legislation mandates that the amount of waste being recycled should be increased. Among others, in its Resource Strategy Plan, the Danish Government decided that at least 60% of food waste generated by the service sector, including in office areas, should be source-sorted and collected separately by 2018. To assess the achievability of these targets, source-sorted food waste and residual waste from office areas was collected and weighed on a daily basis during 133 working days. Waste composition analyses were conducted every week to investigate the efficiency of the source-sorting campaign and the purity of the source-sorted food waste. The moisture content of source-sorted food waste and residual waste fractions, and potential methane production from source-sorted food waste, was also investigated.

Food waste generation equated to 23 ± 5 kg/employee/year, of which 20 ± 5 kg/employee/year was source-sorted, with a considerably high purity of 99%. Residual waste amounted to 10 ± 5 kg/employee/year and consisted mainly of paper (29 ± 13%), plastic (23 ± 9%) and missorted food waste (24 ± 16%). The moisture content of source-sorted food waste was significantly higher (8%) than missorted food waste, and the methane potential of source-sorted food waste was 463 ± 42 mL CH4/g VS. These results show that food waste in office areas offers promising potential for relatively easily collectable and pure source-sorted food waste, suggesting that recycling targets for food waste could be achieved with reasonable logistical ease in office areas.

1. Introduction

In the context of the circular economy and resource efficiency, the Danish Government, in 2013, launched its Resource Strategy Plan, mandating that, by 2018, at least 60% of food waste – that cannot be prevented or reduced – generated by the service sector, including in office areas, should be source-sorted and collected separately (Danish Government, 2013). This source-sorted food waste should be treated biologically to produce biogas and to recover nutrients (Danish Government, 2013). Furthermore, numerous public and private companies and businesses as well as institutions in the service sector are increasingly committed to sustainable development through the prevention, reuse and recycling of their waste (European Commission, 2013; Lang et al., 2011; Phillips et al., 1999). In order to assess the current waste situation, and to allow for any evaluation of performance against target indicators, data on solid waste generation and composition are required. While recently many studies have focused on source-sorted food waste at the household level (Bernstad, 2014; Hansen et al., 2007b; Jansen et al., 2004; Vinnerås et al., 2006), waste data from the service sector in general, and especially office areas, are limited (Christensen and Fruergaard, 2010).

Waste from office areas typically consists of paper, packaging (e.g. board, plastics, metals, etc.), waste from electrical and electronic equipment (WEEE), hazardous waste and unsorted waste associated, for example, with food consumption (Christensen and Fruergaard, 2010). The management of waste from office areas may vary according to countries and office cultures; for instance, in Denmark paper, packaging, WEEE and hazardous waste are source-sorted for either special treatment (e.g. batteries, paint products, waste oil, etc.) or recycling (e.g. paper, board, plastic, WEEE, etc.), while unsorted waste currently is incinerated (Danish EPA, 2014a). This unsorted waste, in many cases, may represent a significant – or the most significant – fraction of generated waste. As an example, the proportion of unsorted waste from the service sector that was incinerated in Denmark in 2012 accounted for up to 31% of the total waste (Danish EPA, 2014b).

Abbreviations: BMP, Biochemical Methane Potential; df, Degree of Freedom; DTU, Technical University of Denmark; FW, Food Waste; HW, Hazardous Waste; RW, Residual Waste; SSFW, Source-Sorted Food Waste; VS, Volatile Solids; TS, Total Solids; WEEE, Waste from Electrical and Electronic Equipment.

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Numerous studies have quantified and characterised unsorted waste generated in canteens, production kitchens and cafeteria in schools, at universities, hotels, restaurants and catering outlets (Armijo de Vega et al., 2008; Cordingley et al., 2011; Katajajuuri et al., 2014; Marthinsen et al., 2012; Mason et al., 2004; Mbuligwe, 2002; Smyth et al., 2010). Mason et al. (2004) analysed source-sorted food waste from canteens, production kitchens and cafeteria at Massey University in New Zealand, but the study did not include office areas. Additionally, the waste generation data were presented as total waste for the university, thus limiting their applicability to other contexts. Composition data on unsorted waste from the service sector, and specifically from office areas, is thus generally very limited, if at all available. In particular, data on source sorting potential and efficiency, as well as the quality (e.g. content of impurities) of food waste generated from employees' lunches, coffee breaks, social events, etc., do not exist, as this waste is often collected and quantified as part of the mixed waste generated by institutions. However, the biologically degradable fraction of this otherwise unsorted waste may represent a valuable source of organic waste. In order to assess whether the collection and specific management of food waste from office areas may contribute significantly to achieving food waste targets, concrete data for waste generation and the quality of the waste are needed. An additional shortfall in many of the abovementioned studies is that the moisture content of waste is rarely measured, even though it represents one of the key parameters affecting, for example, the biological treatment of waste, such as composting (Stentiford and de Bertoldi, 2010), energy recovery (Hulgaard and Vehlow, 2010) and the environmental assessment of waste treatment technology (Clavreul et al., 2012).

The overall aim of this case study was to quantify the potential for source-sorted food waste in office areas, which was done by quantifying food waste generation rates, source sorting efficiencies and the purity of sorted fractions for a selected office area case study. Temporal variations (seasonal and daily) and the influences of a number of employees were investigated. In addition, the moisture content and biochemical methane potential of the collected source-sorted food waste were determined, and the results were then evaluated with respect to how they may contribute to local and national food waste management targets.

2. Materials and methods

2.1. Definitions

In this section, we describe the terminology used in this study. *Food waste* refers to avoidable and unavoidable food waste, including drinks and beverage products (WRAP, 2009), while *residual waste* refers to the remaining unsorted waste when food waste has been taken out; this includes tissue paper, plastic film, food wrapping paper, etc. (see Fig. 1). A *source-sorted waste fraction* refers to a waste fraction that is disposed of in the intended waste bin; for instance, source-sorted food waste is food waste disposed of in a food waste bin. A *missorted waste fraction* refers to a waste fraction disposed of in the wrong waste bin; for example, missorted residual waste is residual waste disposed of in a food waste bin, and vice versa.

In the present study, the following waste fractions were not included: source-sorted recyclable waste (see Section 1), WEEE and batteries, hazardous waste and waste from canteens. The results of statistical analyses are given as probability values (p) and degrees of freedom (df), and the data are presented as mean and standard deviations (Mean ± SD) unless otherwise indicated. The waste generation rates are expressed as mass wet waste per employee at work per working day, or mass wet waste per employee at work per year, assuming 250 working days per year.

2.2. Study area

The study was carried out in the office area of the Department of Environmental Engineering at Technical University of Denmark. The total number of employees was 180 during the waste sampling campaign (DTU Environment, 2013). This office area has four kitchens which are used by the employees for lunch, coffee breaks and social events (e.g. birthdays, breakfast, etc.). The employees can also bring either their food from home or buy from a canteen, supermarket, etc. In general, only hot drinks such as coffee and tea are prepared in the kitchen. The mixed waste generated in this office area is disposed of primarily in the waste bins placed in these kitchens. There are no bins in the corridors for reasons of fire safety. Thus, in the course of this study, two plastic waste bins of 60 L each were placed in each of the four kitchens: (1) food waste bins were used for food leftovers, edible and inedible food, spent coffee grounds with paper filters, tea bags, etc. (see Fig. 1); (2) residual waste bins were used to dispose of all other waste fractions (apart from food waste), including tissue papers, plastic film and food packaging, beverage cartons, aluminium wrapping foil, etc. As a result, eight waste bins were used for this sampling campaign, and they had stickers clearly stating the name of the waste fractions (either source-sorted food waste or residual waste) that should be disposed of in the bins. Sorting guidelines were also available on the department website, while pamphlets explaining the waste sorting campaign were delivered to individual offices (see Fig. 1).

2.3. Waste sampling and analyses

The study was conducted during 133 working days, corresponding to 29 weeks, from 12th February to 31st August 2013. This period covered the winter, spring and summer seasons. The waste was collected separately from each kitchen on a daily basis; however, it was not collected during weekends and public holidays, when the offices were officially closed.

We carried out four analyses. First, we collected and weighed separately the waste from each bin in the four kitchens. This collected waste represented the total mixed waste generated in this office area during the sampling period. However, the food waste that is disposed of via other routes, such as sewer, was not included in this study. Furthermore, we used the existing

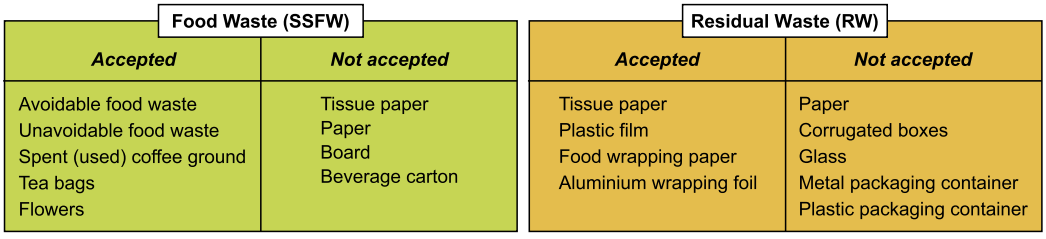

Fig. 1. The waste sorting guide provided to employees.

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