



Short communication

The influence of food waste on dioxin formation during incineration of refuse-derived fuels

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ABSTRACT

We report a preliminary characterization of three refuse-derived fuels (RDFs) produced from recovered wood (RW) and two municipal solid wastes (MSWs) with different food waste contents. The fuels were characterized with respect to elemental composition and emissions of polychlorinated dibenzo-*p*-dioxins (PCDD) and dibenzofurans (PCDF) during combustion in a full-scale incinerator. The first RDF (RDF 1) had a low food waste content because it was based on MSW collected from a region where extensive separation of kitchen waste in the household is common. RDF 2 was based on MSW from a region with no organized separation of kitchen waste and therefore had a higher food waste content. A RW fuel with no added MSW was combusted to provide reference data.

RDF 1 had very favourable fuel quality and PCDD/F emissions. In particular, its combustion generated lower PCDD/F concentrations (14.6 ng/m³) than that of RDF 2 (23.9 ng/m³) or RW (22.6 ng/m³). This may have been because its relatively high heating value increased its combustion efficiency and the relatively high Cl and Fe contents of RDF 2 promoted PCDD/F formation and chlorination. Both RDF materials had lower moisture contents and higher heating values than the RW fuel.

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1. Introduction

According to statistics from the Swedish Waste Management and Recycling association (personal communication) 179 of the 289 local communities in Sweden have introduced a separate collection system for food waste. An important benefit of such systems is that they allow the nutrients in food waste to be utilized as organic fertilizers while the energy it contains can be used to produce vehicle fuels (biogas). An additional effect of the separate collection system is that the residual waste sent for energy recovery is dryer and has lower Cl content than it would otherwise, enabling its conversion into a high quality refuse-derived fuel (RDF).

The study presented herein compared two regions (referred to as Regions 1 and 2) that are similar in many respects (i.e. urbanization, population density, industrial profile, etc.) but differ greatly in the extent of food waste separation among their households. During the studied period, 65–70% of the food waste generated in Region 1 was collected in a separate collection system.

Conversely, Region 2 had yet to implement a separate collection system for food waste and so all of its food waste was treated as municipal solid waste (MSW) and sent for incineration.

The availability of RDF materials from both regions made it possible to determine how the presence of food waste in the RDF affects its quality as a fuel and the formation of polychlorinated dibenzo-*p*-dioxins (PCDD) and dibenzofurans (PCDF) during combustion. This was done in a preliminary investigation whose main objective was to characterize RDFs made by mixing recovered wood (RW) and MSW with different content of food waste in terms of their elemental composition and emissions of PCDD and PCDF during combustion in a full-scale incinerator. As a comparison, RW was also combusted with no added MSW.

PCDD and PCDF are pollutants that are formed as by-products during thermal processes such as MSW incineration. For environmental safety reasons, plants performing such processes must incorporate extensive flue gas treatment systems to minimize PCDD/F emissions. Both RW- and MSW-derived fuels can be combusted in district heating plants. However, the cost of operating RW plants is appreciably lower than that for MSW incinerators, which is due to flue gas emission regulations, flue gas acidity and robustness of the process. It would therefore be socially and economically beneficial to find a way of pre-treating MSW and mixing

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it with RW to form a blended RDF suitable for RW plants, provided that regulatory requirements concerning organic and inorganic emissions would be met. Such a blended fuel would have to satisfy stringent quality and combustion efficiency criteria.

2. Materials and methods

2.1. Fuel preparation

Three different fuels were studied: two RDF fuels (denoted RDF 1 and 2) made from MSW containing different amounts of food waste, and recovered wood (referred to as RW). RDF 1 was produced from MSW collected in Region 1 and RDF 2 from MSW collected in Region 2. Region 1 has a well-established system for source separation of food waste and therefore produces MSW with a low content (20–25%) [1] of food waste compared to that from Region 2, for which the food waste content is around 45% [1]. The RDFs were produced by shredding and screening the MSW in a grinder (Doppstadt DW 3060) and a 100 mm drum screen with a length of 5 m (Doppstadt SM 518). The shredded and screened MSWs were then mixed with RW in ratio of 25:75 RDF:RW and shredded again. In this way, the MSW was separated into a fuel fraction and a heavy fraction. The heavy fraction contains items that are unsuitable for combustion, such as metal objects (which are removed) and some organic material (which is separated and subsequently treated in a large-scale composting process). The shredding and blending processes contribute to the homogenization and drying of the fuel.

2.2. Experimental campaign and sample collection

The RDFs were combusted in a district heating plant with a modern 36 MW furnace that combusts approximately 65,000 tons of fuel per year (Fig. 1). The plant's normal fuel is RW, although it also burns smaller quantities of paper and plastic materials. Each RDF was fed into the furnace for at least 24 h before flue gas sampling (raw gas only) was performed, in duplicate, for 1 h at approx. 140 °C. The order of the experimental runs was 1: RW; 2: RDF 1 and 3: RDF 2, with the purpose to minimize carry-over effects from runs using fuels which would be expected to generate relatively

high PCDD and PCDF concentrations to those generating lower concentrations. Sampling was performed isokinetically using the cooled probe polyurethane foam plug sampling technique according to the EN 1948:1 standard method [2]. The concentrations of target analytes were normalized to 1 atm, 0 °C, dry gas, and 11% O₂. A field blank was prepared at the site.

The RDFs that were fed into the system were sampled three times during each experiment, 1–2 kg per sample. These samples were then combined to form one pooled sample for each of the three fuel types used in this study. Sub-samples were then taken from the pooled samples in order to determine their elemental composition and fuel properties.

2.3. Laboratory work and analytical procedures

All fuels were characterized with respect to heating value, moisture and ash content, and elemental composition (Table 1). The main part of these analyses were performed by Bränslelaboratoriet in Umeå, Sweden, according to standard methods SS 187170 (moisture content) SS-EN 14775 and 15403 (ash content), and SS-EN 14918 and 15400 (heating value). The elemental content was analysed by ALS Scandinavia in Luleå, Sweden, according to EPA methods (modified) 200.7 and 200.8.

Standard addition, filtration and extraction of flue gas samples were performed using methods that have been described previously [3,4], with the modification that fractionation was performed using a 0.5 g column containing a 1:11.7 (w:w) mixture of AX21 carbon (Anderson Development Company) and Celite 545 (Fluka). All laboratory work was performed according to validated methods.

Samples were analyzed for PC₁₋₈DD and PC₁₋₈DF by GC-HRMS using an AutoSpec ULTIMA NT 2000D high-resolution mass spectrometer (Waters Corporation, Milford, MA). PC₁₋₈DD and PC₁₋₈DF were determined using a J&W Scientific DB-5MS (60 m, 0.25 mm i.d., 0.25 µm) capillary column. The mass spectrometers were operated in electron impact ionization/selected ion monitoring mode and the analytes were quantified using the isotope dilution technique. Target analytes (2,3,7,8-substituted PCDD and PCDF congeners, and the mono- to octachlorinated homologues) were identified by comparing (i) their retention times to those of

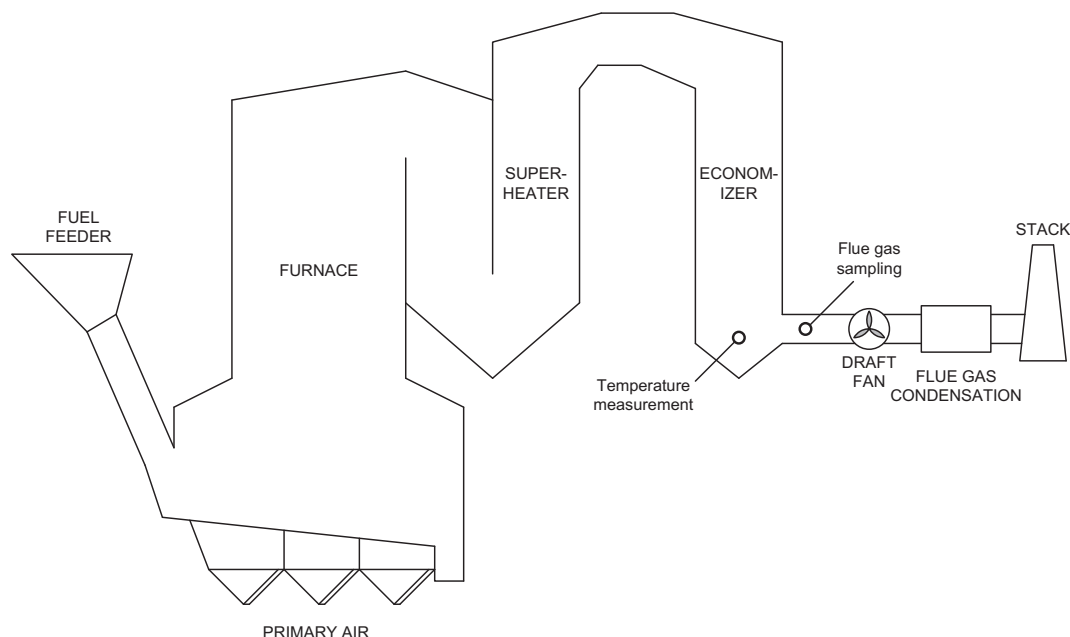


Fig. 1. Schematic representation of the combustion facility.

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