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Characterization and mass balance of PCDD/Fs during the co-combustion of sewage sludge in a grate-type municipal solid waste incineration

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Abstract

The emission and distribution characteristics of polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) were investigated during the co-combustion of sewage sludge (SS) with municipal solid waste (MSW) in a grate-type furnace, South China. On the output side, the stack gas, slag and fly ash with the dioxin levels of 10.75 pg I-TEQ/Nm^3, 4.98 pg I-TEQ/g and 294.9 pg I-TEQ/g, respectively, showed similarities in congener profiles. However, the input side presented a significantly different congener profiles compared to that in the output side, which may attribute to the de novo synthesis. The predominant PCDD/Fs contribution (>90%) in fly ash suggested it as the major sink of dioxins in the output side. A positive mass balance of PCDD/Fs with the value of 12.09 μg I-TEQ/t-MF was demonstrated.

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Keywords: polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs); co-combustion; sewage sludge; municipal solid waste; mass balance

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1. Introduction

The accelerated economic development and urbanization process have brought a considerable volume of sewage sludges (SS) which comprise high levels of water, organic matter, and pathogenic agent contents. The production of SS in China has dramatically increased at an annual rate of 4% in recent years[1]. Due to the shortcomings on fertilizer recycling, landfilling, and sea dumping, incineration has been considered as an effective method for SS disposal due to its advantages on stabilization, volume reduction and resource recovery[2]. Many countries strongly support the co-incineration of SS as supplementary fuel in the operating incineration facilities, such as coal-fired power plants, cement kilns, brick kilns and municipal solid waste incinerators (MSWIs).

Concentrated public concerns have been raised on polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) emission from incinerators, owing to their high toxicity and associated adverse health implications. Extensive studies have been conducted to investigate the possible routes and mechanism leading to the formation of PCDD/Fs[3-5], some of which referred to mono-combustion and co-combustion of SS. Unfortunately, data on the emission and characterization of PCDD/Fs are still limited. Furthermore, reports on co-incineration of semi-dried sludge are rare, especially concerning co-incineration with MSW in a grate furnace incinerator. The continuous improvement of incineration technology and the increasing amounts of MSWIs provide possibility for co-combustion of SS with MSW in China[6]. It is of necessity to assess the real emissions of dioxin from all by-products derived from a modern MSWI, for better understanding the environmental feasibility of co-incineration of SS with MSW in China.

Therefore in the present study, emissions and congener profiles of PCDD/Fs were demonstrated in the input and output sides from a operating MSWI. Dioxin mass balance was as well calculated to determine how and where dioxins emitted. To our best knowledge, this is the first comprehensive study conducted on a field grate furnace to assess the real situation of PCDD/Fs characterization in China.

2. Materials and Methods

2.1. Basic Information on the MSWI.

The investigation was carried out on a continuously operating modern MSWI in South China. The capacity of the MSWI is 1500 tons per day. The Mitsubishi-Martin grate-type furnace consists of three identical incinerating units, with each the separate heat recovery system and air pollutant control devices (APCDs), including semi-dry scrubber (SDS), activated carbon injection (ACI), and bag filter (BG). $Ca(OH)_2$ emulsion are added to trap the acid gases in the SDS. The co-incineration study was performed on one of the three units. The SS, obtained from a municipal waste water treatment plant nearby, was dewatered to semi-dried SS with the moisture content of approximately 30 wt.% before its mix with MSW. The operating conditions and parameters of the MSWI are depicted in Table 1.

Table 1. Operating conditions and Parameters of the MSWI.

Operating conditions	Parameters
Daily capacity (t/d)	1500
Incineration units	3
Operation time (h/d)	24
Production of fly ashes per unit (t/d)	43
Production of slag per unit (t/d)	161
Flue gas per unit (Nm^3/h)	109000
Fuel components	SS : MSW = 1:10

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