IMPACT OF MUNICIPAL SOLID WASTE INCINEARATORS ON AMBIENT SOIL PCDD/F LEVELS: A CASE STUDY IN HANGZHOU, CHINA

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Introduction

Identification of the major sources of polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) in the environment is considered as the preliminary step to efficiently control and reduce PCDD/F pollution [1]. Recent studies on the inventories of potential PCDD/F emission sources in European countries indicated that although the emission levels have been significantly reduced in the past two decades, municipal solid waste incineration (MSWI) is still one of the most important PCDD/F contributors [2]. As for China, the construction of MSWI plants has been booming since 2000 owing to the lack of landfill sites for the waste and unsuccessful management of composting. It is estimated that by the year of 2015, 200 incineration facilities with a 500 ton/day capacity will be operated in medium-sized cities and metropolitan areas [3]. However, to date, in China only a few studies have examined the occurrence of PCDD/Fs in the environmental sinks, i.e., soil and sediment, and are mainly focused on the schistosomiasis and E-waste recycling area [4]. Accordingly, a large data gap must be urgently filled to get a better understanding of the environmental impact imposed by the emissions of PCDD/Fs from the municipal solid waste incinerators (MSWIs). In September, 2006, our work group initiated an investigation of agricultural soil samples in the vicinity of a MSWI plant in Hangzhou, China [5]. The analyses of homologue and isomer patterns of soils and potential PCDD/F sources indicated that the studying area was primarily influenced by various combustion sources [5,6]. In order to have an in-depth view of the relative importance of PCDD/F potential sources in the vicinity of the MSWI plant where industrial and residential area coexist, a second survey was performed one year later at the same sites as the previous ones. In this paper, the environmental impact of MSWIs was evaluated by the comparisons of predicted and measured ambient agricultural soil PCDD/F variations with respect to increasing distances from the stack.

Material and Methods

The detailed descriptions of the study area as well as the MSWI plant were previously reported [6,7]. Briefly, it is a satellite town (up to 37 000 inhabitants) in northeast part of Hangzhou, China, with a dominant land use of agriculture (57%) (Fig.1). The MSWI plant is situated just in the center of a satellite town, adjacent to two motorways with heavy traffic and with a daily treatment capacity of 800 t since 2003. All of flue gases are purified by the air pollution control device consists of a semi-dry scrubber and a bag-house filter. Consequently, the emission levels measured during its fully operational in 2007 were generally below the national legal limit. Besides, a small-scale hazardous waste incinerator (HWI) was located 800 m northward to the MSWIs and had once been occasionally in operation during 2002 and 2004. In September, 2007, a second round of soil sampling was performed at the same places with the aid of a handheld GPS device (~ 10 m of accuracy) in a period of two days. The location of the MSWI plant, HWI plant and the distribution of soil samples within a radius of 1.5 km from the stack were depicted in Fig. 1. Also illustrated was the wind frequency distribution diagram during the two sampling events obtained from the Meteorological Bureau of Hangzhou. The details of soil sampling techniques, preparations and PCDD/F analytical procedures were presented elsewhere [5]. In order to assess the relative environmental impact of MSWIs, the ratios of predicted to those of measured ambient agricultural soil PCDD/F variations with respect to increasing distances from the stack was evaluated. Measured soil PCDD/F variations were calculated by subtracting the congener concentrations of initial survey from those of current investigation. Given the long half-lives of PCDD/Fs in soil (>10 years), the decrease of PCDD/F concentrations could be due to the overall sampling and analytical uncertainties [8]. Therefore, when this subtraction resulted in a concentration less than 0, the concentration was set to 0. Estimations of soil PCDD/F variations due to the emissions of MSWIs were obtained based on the sequential hourly surface meteorological data (2006-2007) following the previously reported modeling procedures [9]. The national legal limit of 1 ng I-TEQ Nm^{-3} was used in the model exercise for conservative purpose. As the congener profile varied from incinerator to incinerator and from events to events, the previously reported average fingerprint was adopted in this study [5]. For convenience of comparison, soil samples in the vicinity of the MSWI plant were clustered into six groups according to their distances from the stack, i.e., 0~250, 250~500, 500~750, 750~1000, 1000~1500 and 1500~3000 m (Group a~f), respectively, and all the PCDD/F concentrations were expressed on a mean basis.

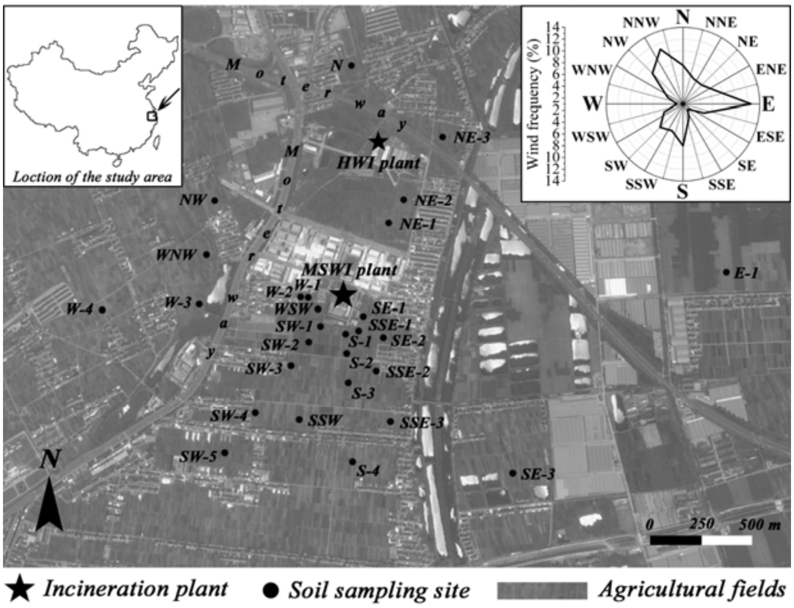

Figure 1: Distribution of agricultural soil samples in the vicinity of the MSWI plant

Results and discussion:

PCDD/F variations in agricultural soil in the vicinity of the MSWI plant

The variations of I-TEQ values among six soil groups with increasing distances are 0.52, 0.43, 0.37, 0.47, 0.29

and 0.41 ng I-TEQ kg^{-1}, respectively, which are relatively higher than those collected in the vicinity of a MSWI plant with even higher emission levels (~3 ng I-TEQ Nm^{-3}) [10]. This indicates that the MSWIs might not be the dominant contributor to the total soil variations within the study area. A decline of the I-TEQ values with increasing distances from the stack could only be observed for three neighboring groups, i.e., Group a, b, and c. Besides, the I-TEQ values of soil samples in Group f, which situate far away from the facility (>1.5 km) are even higher than those of Group b, indicating that other potential PCDD/F sources rather than MSWIs dominate in this sub-areas. Among the 17 congeners, OCDD shows the highest variation for all groups, followed by 1,2,3,4,6,7,8-HpCDF, OCDF and 1,2,3,4,6,7,8-HpCDD. This is in agreement with the relative abundances presented in the congener profiles of both surveys.

Contributory of MSWIs to the total soil PCDD/F variations with increasing distances from the stack

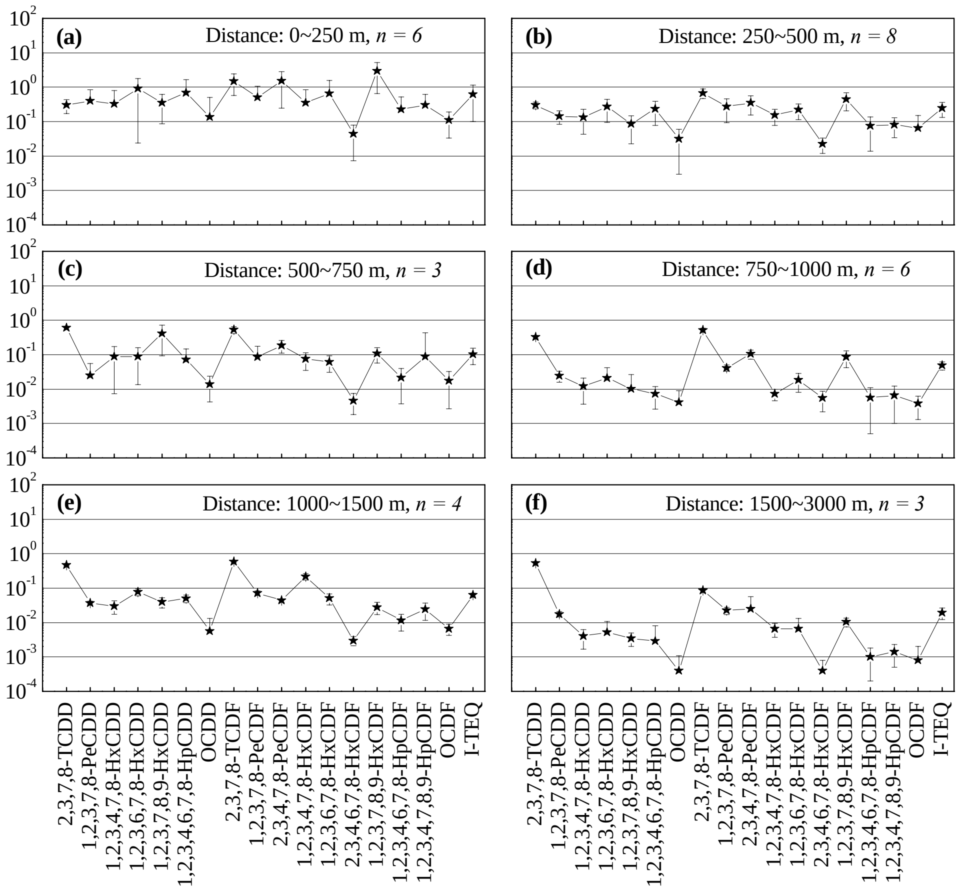

Figure 2: Contributory of MSWIs to the total soil PCDD/F variations at various distances from the stack

The predictions of soil I-TEQ variations at various distances due to the emissions from the MSWIs are 0.32, 0.11, 0.04, 0.02, 0.02 and 0.01 ng I-TEQ kg^{-1}, respectively. A systematic decease of I-TEQ values with increasing distance from the stack can be observed. It is obvious that the contributory of MSWIs to the total soil PCDD/F variations decreases with increasing distances from the facility, especially for the I-TEQ values (Fig.2). The highest impact of MSWIs is on the adjacent area (<250 m), with ratios of 0.66 and 0.62 for total congener and

I-TEQ variations, respectively. As for sub-area located within 1.5 to 3.0 km from the stack (Fig. 2f), the corresponding contributions of MSWIs are 0.04 and 0.02, respectively, which is negligible compared with other potential PCDD/F sources. The relative impact of MSWIs on the ambient agricultural soil located within a radius of 250~1500 m from the facility is of medium level between those of Group a and f, with only Group b having a contributory greater than 0.1 for both total congener and I-TEQ variations (0.21 and 0.24, respectively). To sum up, the influence of PCDD/F emissions from the MSWIs on the ambient agricultural soil is limited and focused on the adjacent area (<500 m). This is consistent with the results obtained from the national monitoring of PCDD/Fs in soil samples around incinerators in Korea [11]. PCDD/F potential sources including open dumpling sites, open burning of crop residues, diesel and leaded gas-fueled vehicles, small wood-fueled combustors and MSWI bottom ash might play a more important role in certain sub-areas, especially for those located far away from the stack (>1.5 km). In order to efficiently reduce and control PCDD/F pollution in agricultural fields in the vicinity of the MSWI plant, further work is needed to quantify the contributories of all existing potential PCDD/F source and determine the dominating factors among the respective sub-area.

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