MEASURED AND PREDICTED PCDD/F CONCENTRATIONS IN AGRICULTURAL SOILS NEAR TO A MUNICIPAL SOLID WASTE INCINERATOR PLANT IN CHINA

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Abstract

The ISCST3 model was applied to predict the international-toxic equivalent (I-TEQ) values of polychlorinated-p-dioxins and dibenzofurans (PCDD/Fs) of agricultural soil within a radius of 1.5 km from a Chinese municipal solid waste incinerator (MSWI) plant after its 4-year operation in Hangzhou, China. The modeling results show that the predictions are generally lower than that of the observations, and the degree of underestimation seemed to be greater the further downwind one gets. Nevertheless, the predicted values demonstrate the same trend of the observed ones, and are generally within a factor of 10 of observations, indicating that the ISCST3 model could be extrapolated to serve as a screen means to predict the soil I-TEQ values in the vicinity of the MSW plant.

Introduction

It is well recognized that municipal solid waste incineration is a major source of dioxin release. Consequently, determinations and assessments of multimedia dioxins levels in the vicinity of municipal solid waste incinerator (MSWI) have been widely performed. In the last few years, a variety of dispersion and deposition models have been introduced to further assess the impact of MSWI on various environmental media, among which the ISCST3 model has the highest popularity[1-4]. The central purpose of this study was to test the performance of the ISCST3 model in predicting polychlorinated dibenzo-p-dioxins and dibenzofurans concentrations (subsequently referred to as PCDD/Fs) in agricultural soils in the vicinity of a municipal solid waste plant in China.

Materials and Methods

The MSW plant referred in this study is located in a satellite town, in Hangzhou, China. It is equipped with three fluidized bed incinerators (FBIs) and began its operation of first two lines in 2002, and has been in full operation with a total daily capacity of 0.8 million kg 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 level measured during its fully operational in 2003 was quite below the national legal limit[5]. There are two motorways with heavy traffic in its west and north sides. Besides, a small-scale hazardous waste incinerator (HWI), which was 0.8 km northward to the plant, had once occasionally in operation during 2002 and 2004. However, the capacity and PCDD/F emission data from this HWI were not available due to secrecy.

The sampling points were selected according to the wind rose resulting from pluriannual observations

(2002-2005). Thirty-three soil samples (20 cm of depth) were collected from agricultural land in a two-day period, in September 2006. The exact sampling points were determined and recorded within ~10 m of accuracy by a handheld GPS device (Meridian Color, Thales Navigation, USA). Twenty-nine samples were collected mainly in the historical prevailing downwind directions (W, S, SE, SSE, SW and NE) (Fig. 1). The location of the MSWI, HWI and the sampling sites within a radius of 2 km from the stack were depicted in Fig.1 by transforming the coordinate of each point into the Geographic Information System (GIS) software packages of Google Earth (2006).

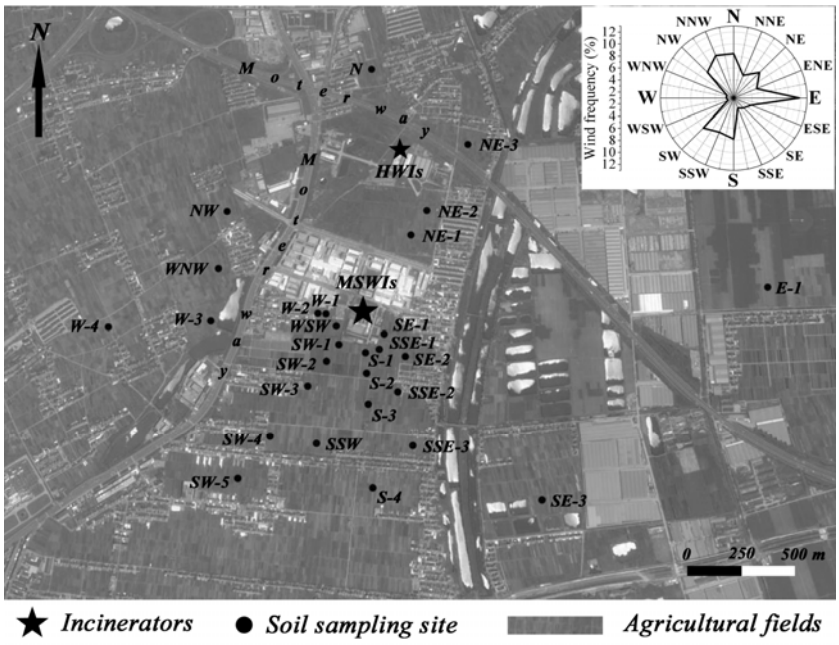

Fig.1. Schematic of the distribution of soil samples around the MSW plant

Approximately 2 kg of soil was taken at each site, and 10 g (dry matter) of soil sample (60-mesh) were used for PCDD/F analysis following the Method of USEPA 1613. The results showed that the PCDD/F concentrations in soils were ranged from 0.39 to 5.04 pg I-TEQ g^{-1}, with an average and a median value of 1.22 and 0.84 pg I-TEQ g^{-1}, respectively. It should be noted that the unusually high values were only found in three soil samples (i.e., WSW, NW and N), with concentrations in sequence of 5.04, 4.03 and 3.56 pg I-TEQ g^{-1}, respectively. The sample of WSW was collected just outside the property of the incinerator and the other two (NW and N) were adjacent to motorways with heavy traffic and downwind the HWI (Fig. 1). The high PCDD/F concentrations of these three samples might be attributed to uncontrolled dispersion of fly ash and fugitive emission sources such as motor vehicles and HWI, respectively. Therefore, these three soil samples were treated as outliers and excluded from the subsequent modeling.

The modeling procedures as well as the model input assumptions and parameters are all referred to Lober et al. (2000) except for a few modifications listed in Table 1. As the 2,3,4,7,8-PeCDF was the maker congener in the flue gas, and was directly proportional to the I-TEQ, therefore, for convenience, only the2,3,4,7,8-PeCDF was modeled to predict the enhancement of I-TEQ values in agricultural soils caused by the 5 years operating of

the MSW plant[6]. It should be mentioned that the modeling procedure were conducted through the intuitive graphical software of ISC-AERMOD View 5.3 which was developed by the Lakes Environmental Corporation: http://www.weblakes.com.

Table.1 Parameter values for the PCDD/F concentration modeling of soils

Description	Parameter value	Description	Parameter value
Base elevation	12 m	Stack height	60 m
Stack inside diameter	3.24 m	Stack temperature	398 K
Exit velocity	12 m s^{-1}	Meteorological data	2002~2005
Emission level	0.196 ng TEQ m^{-3}	Extrapolated to	0.419 g TEQ yr^{-1}

Results and Discussion

The modeling results of this study are shown in Fig.2 using the Universal Transverse Mercator (UTM) coordinates. Small circles filling with white color are soil sampling locations, whereas the circles in red color are distance indicators (250, 750 and 1500 m in sequence).

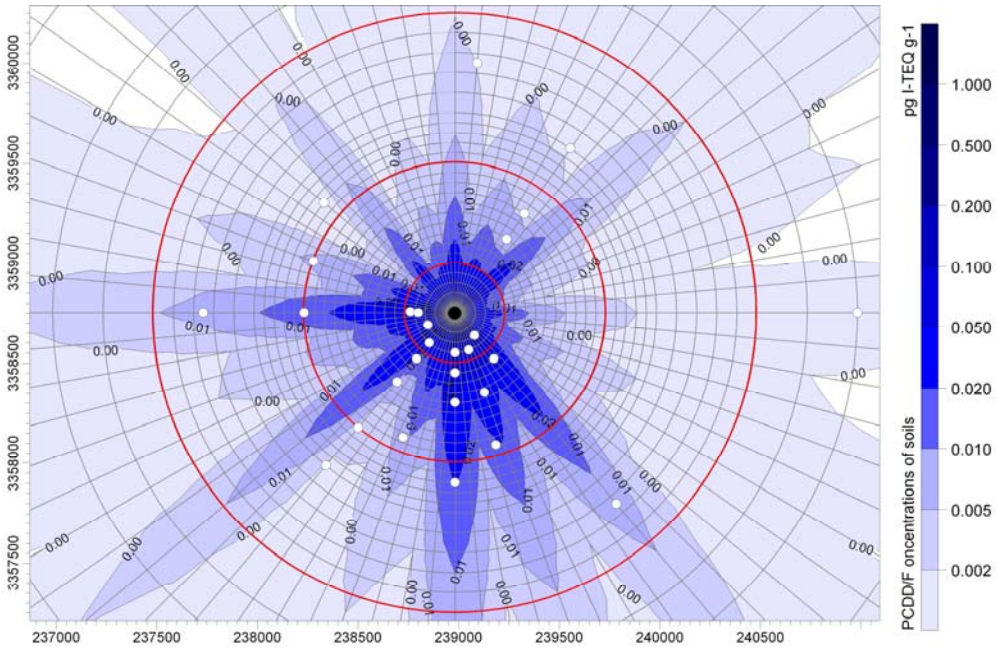

Fig.2. Predicted PCDD/F concentrations of agricultural soils in the vicinity of the MSW plant

The predicted PCDD/F concentrations for the agricultural soil samples in the vicinity of the MSW plant are all below the level of 0.200 pg I-TEQ g^{-1}, indicating a low environmental risk originating from the emission s of the MSWIs. As the concentrations of the agricultural soils prior to the construction of the MSW plant were not available, therefore, the concentration of soil sample (S5) located 3 km south of the plant was arbitrarily served as the background PCDD/F level of the local area. The level of S5 (0.81 pg I-TEQ g^{-1}) was subtracted from each

of the 22 observed soil measurements within 1.5 km radius of the plant; when this subtraction resulted in a concentration less than 0, the concentration was set to 0.

Table.2. Comparisons of the averaged increment of the predicted and observed PCDD/F concentrations in various distances and directions (pg I-TEQ g^{-1}).

Distance (m)	Predicted	Observed	Direction	Predicted	Observed
250	0.110	0.300	SW	0.012	0.108
750	0.026	0.118	W	0.058	0.301
1500	0.008	0.065	SSE	0.067	0.302

Comparisons of the averaged increment of both the modeled and measured PCDD/F concentrations in various distances and directions are listed in Table 2. It can be seen that the predicted values are all below the observed ones, and are generally within a factor of 10 of observations. Besides, the ISCST3 model seems proportionally underestimate the concentration to a greater degree the further downwind one gets. For instance, the averaged predicted value for the sampling sites within a radius of 250 m is about one third that of the observed one, whereas for sampling sites between 750 and 1500 m, the modeled value is only one eighth that of the measured one. However, the degree of under-prediction for various directions seems to be more insensitive than the distances, ranging from a factor of 5 to 9.

The underestimation of the modeling might be ascribed as two reasons: firstly, the modeling does not compromise the algorithms of wet/dry vapor-phase deposition, which is an important deposition process for the less chlorinated PCDD/Fs such as the 2,3,4,7,8- PeCDF (the vapor fraction for PeCDF was 0.20); secondly, the sampling area belongs to a satellite town which contains other PCDD/F sources such as the HWIs, motor vehicles, and the scattered open burning. Nevertheless, the predicted values showed the same trend of the observed ones, and can be extrapolated to serve as the screen evaluation of the soil concentrations around the MSW plant in the future.

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