THE IMPACT OF PARAMETERS ON EVALUATION OF DIOXIN CONCENTRATIONS IN SOIL NEAR THE MUNICIPAL SOLID WASTE INCINERATOR VIA ISCST3 MODEL

Jian-hua Y [1], Meng-xia X [1], Sheng-yong L [1], Xiao-dong L [1], Tong C [1], Ming-jiang N [1], Ke-fa C [1]

[1]State Key Laboratory of Clean Energy Utilization, Institute for Thermal Power Engineering of Zhejiang University, Hangzhou, China, 310027

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.[1-5] This paper aims to further explore the impact of meteorology and plume depletion by dry and wet removal processes on evaluation of dioxin concentrations in soil near the MSWI via the ISCST3 model and is based on the research work executed by Matthew Lorber around the CMSWTE (Columbus Municipal Solid Waste-to-Energy facility in Columbus, OH, U.S.A.) [2].

Materials and Methods

The complete descriptions of CMSWTE, including the plant background information, ISCST3 and soil model input assumptions and parameters, soil sampling sites and the observed homologue-specific concentrations of dioxins in soil around the plant are all referred to the paper.[2] The modeling area (10km×12km) , the location of the CMSWTE and the distribution of 31 soil samples around the CMSWTE are depicted in Figure 1.

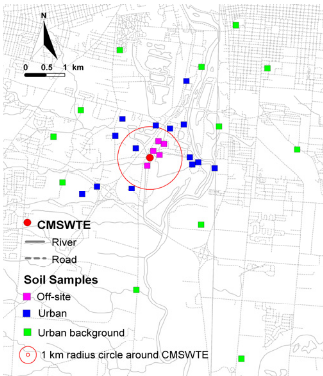

Figure 1. Schematic of the distribution of soil samples around the CMSWTE

There are five key factors in ISCST3 soil concentration modeling, namely emission characteristics, meteorology, terrain, dioxins removal processes from atmosphere to soil, and the non-steady-state of dioxins concentrations in soil.[6] However, this paper is only focused on two factors: meteorology and dioxin removal processes, in which three parameters including meteorology, plume depletion by dry and wet removal are selected. The arrangements of the three parameters for different ISCST3 model runs are provided in table 1. The predictions of different model runs are computed by the intuitive graphical software of ISC-AERMOD View 5.0.0 which is developed by the Lakes Environmental Corporation: http://www.weblakes.com.

Table 1. Arrangements of three parameters for different ISCST3 model runs

No.	Meteorology	Dry Removal	Wet Removal	No.	Meteorology	Dry Removal	Wet Removal
1	1985	No	No	5	1989	Yes	No
2	1987	No	No	6	1989	No	Yes
3	1989	No	No	7	1989	Yes	Yes
4	1985~1989	No	No				

Results and Discussion

The computational results with observed data concerning the effect of meteorology and plume removal processes from 1-4 and 3, 5-7 model runs are provided in Table 2 and Table 3, respectively.

Table 2. Comparisons of computational results with the observed data concerning the effect of meteorology [a]

	Off-site					Urban					Urban background				
	1	2	3	4	Obs	1	2	3	4	Obs	1	2	3	4	Obs
TCDD	31	26	44	31	98	12	11	13	12	19	6	5	7	6	<1
PCDD	166	139	237	166	64	63	59	69	62	13	32	26	36	31	2
HxCDD	572	479	817	574	150	217	203	237	214	43	109	89	125	108	4
HpCDD	988	828	1412	992	654	375	351	409	370	154	188	155	215	187	20
OCDD	1134	950	1619	1138	2901	430	402	470	424	613	216	177	247	214	150
TCDF	305	256	436	306	153	116	108	126	114	35	58	48	67	58	2
PCDF	690	578	986	693	194	262	245	286	258	33	132	108	150	130	5
HxCDF	1203	1008	1719	1208	116	456	427	499	450	22	230	188	262	227	3
HpCDF	1192	999	1703	1197	193	452	423	494	446	37	227	186	260	225	5
OCDF	333	279	476	335	88	126	118	138	125	15	64	52	73	63	3

[a]Concentrations in pg g^{-1}, background is subtracted for all the data, Obs=Observations, same set for table 3.

As the modeling result is proportional to the original concentration in the flue gas and the particle fraction, therefore, the homologue of OCDD is most sensitive to the variation of meteorology. However, it can be seen from table 2 that the OCDD concentrations resulted from different model runs as a whole exhibit little changes. This is mainly due to the slight variations of the resultant wind vectors (represented by the spike line) between different modeling years (Figure 2).

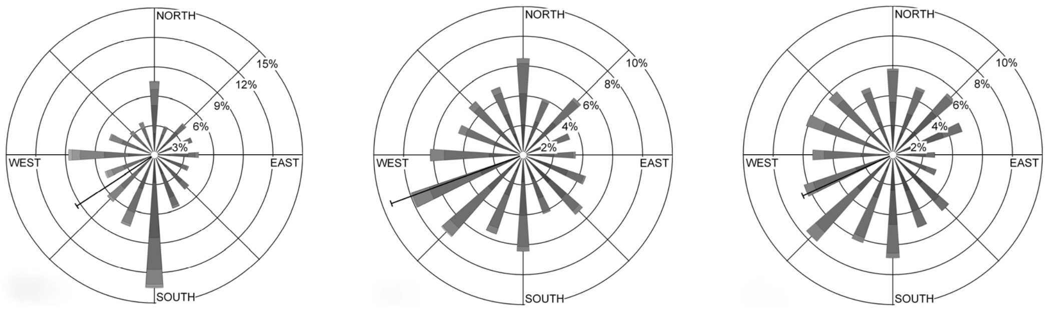

Figure 2. Schematic of the variations of the resultant wind vectors between different modeling years (1985, 1987 and 1989 in sequence)

Table 3. Comparisons of computational results with the observed data concerning the effect of removal processes

	Off-site					Urban					Urban background				
	3	5	6	7	Obs	3	5	6	7	Obs	3	5	6	7	Obs
TCDD	44	44	14	12	98	13	12	3	2	19	7	5	2	<1	<1
PCDD	237	238	76	66	64	69	64	18	9	13	36	28	12	2	2
HxCDD	817	822	262	228	150	237	222	60	31	43	125	96	41	8	4
HpCDD	1412	1421	453	394	654	409	384	105	53	154	215	166	71	14	20
OCDD	1619	1630	520	452	2901	470	441	120	61	613	247	191	81	16	150
TCDF	436	439	140	122	153	126	119	32	16	35	67	51	22	4	2
PCDF	986	992	317	275	194	286	268	73	37	33	150	116	50	10	5
HxCDF	1719	1730	552	479	116	499	468	127	65	22	262	202	86	17	3
HpCDF	1703	1715	547	475	193	494	463	126	64	37	260	201	86	17	5
OCDF	476	479	153	133	88	138	130	35	18	15	73	56	24	5	3

Examination of the data in table 3 reveals the clear trend that the degree of overestimations of homologue-specific dioxin concentrations are greatly decreased by the integration of the plume wet removal algorithm, but to relatively lesser extent for the plume dry removal algorithm. The one-way ANOVA test of LSD by SPSS is introduced to further analyze the differentiation in the impact of different model parameters. It should be noted that in order to eliminate the influence of different emission rates and vapor-to- particle ratios of various homologues on the sensitivity testing, the depositions of the total particulates instead of the homologue-specific dioxin concentrations are selected for statistical analyzing. The results of the parameters significance testing are listed in table 4, in which the No.3 model run is assumed to be the control basis.

Table 4 provides an in-depth view of the impact of different parameters. It is observed that the differences between the No. 6 model run and the control basis are significant for all the three soil clusters, indicating that the wet removal process has a great impact on the evaluation of dioxin concentrations in soil. However, the differences between the No. 5 model run and the control basis show a contrasting trend, which indicates that the dry removal process has a little impact on the model output. The situation of the meteorology seems to be complicated, but generally has an intermediate impact between the wet and dry removal processes.

Table 4. Results of the LSD testing for various model runs

Model run	Off-site		Urban		Urban background	
	M.D.[a]	Sig.[b]	M.D.[a]	Sig.[b]	M.D.[a]	Sig.[b]
1	.5612	.236	.0463	.586	.0357	.331
2	.7738	.106	.0781	.359	.0807*	.030
4	.5567	.239	.0528	.535	.0383	.298
5	-.0128	.978	.0337	.692	.0652	.078
6	1.2709*	.010	.4045*	.000	.1916*	.000
7	1.3498*	.007	.4727*	.000	.2668*	.000

[a]M.D. is the mean difference between control basis and specific model run, [b]significance level is at .05

It should be noted that almost all the model runs under-predict the homologue of OCDD, especially for the off-site and urban areas. This might be contributed to the unique partitioning behavior of OCDD in the atmosphere.[2] Therefore, the model run incorporated with the sole dry deposition process might consequently offset the under-prediction and appears to be more accurate in OCDD modeling.

This study demonstrates that among the above mentioned three parameters, the ISCST3 model is most sensitive to the wet removal process, followed meteorology and is most insensitive to the dry removal process, while it is used to evaluate the homologue-specific concentrations of dioxins in soil near the MSWI. In order to get an overall view of the impact of different parameters, additional research work on other parameters will be followed.

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References

1. Basham Jp, Whitwell. *Atmospheric Environment* 1999;33:3405
2. Lorber M, Eschenroeder A, Robinson R. *Atomspheric Environment* 2000;34:3995
3. Hwong WM, Yen LL, Chang CC. *Environment International* 2002;28:103
4. Karademir A. *Environment International* 2004;30:1027
5. Choi SD, Chang YS. *The 25th International Symposium on Halogenated Environmental Organic Pollutants and Persistent Organic Pollutants (POPs)* 2005;1180
6. Yoshida K, Ikeda S, Nakanishi J, Tsuzuki N. *Chemosphere* 2001;45:1209