# STATISTICAL ANALYSIS OF TOXIC PCDD/F FROM WASTE INCINERATION FACILITIES

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## 1. Introduction

Waste incineration, including municipal, hospital and hazardous or chemical waste incinerations, is one of major contributors of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F) production poured into the environments. The formation and degradation mechanisms of PCDD/F have been extensively studied by laboratory –scale experiments and several mechanisms e.g. chlorination[1], dechlorination[2] and phenol condensation[3] pathways, have been proposed. Specific isomer patterns can be expected from each mechanism. The studies suggest that the dominant formation mechanism of PCDD is phenol condensation and that of PCDF is chlorination and/or dechlorination. Statistical analyses can contribute to control or prevent PCDD/F formation and provide insight to the chemical mechanisms of their formation and degradation in practical incineration facilities[4].

## 2. Experiments

The sampling, cleaning up and analytical procedures of flue gases from different types of waste incineration facilities have been reported elsewhere[5, 6]. All the original data used in this article, 26 incineration facilities (7 hospital, 7 hazardous/chemical and 12 municipal incineration facilities) and total 143 samples from these facilities (detailed operation conditions of each facilities not considered), of PCDD/F concentrations are all from our laboratory and analyzed for respective waste incineration factories.

## 3. Results and discussions

### *3.1 Principal component analysis of different types of waste incineration facilities*

Principal component analysis is used to reveal the relationships between different sampling cases for each type of incineration facilities. The objects are the sampling cases and the variables toxic PCDD/F isomer concentrations. The first two principal components i.e. PC1 and PC2 give a very good description of the majority of samples and explain 80.90%, 72.51% and 81.69% of the variances for hospital, hazardous/chemical and municipal incineration facilities respectively (Table 1). Each principal component corresponds to respective combustion isomer patterns[7]. The principal component analysis shows there is no one common combustion pattern for PCDD/F isomers, suggesting that different formation mechanism plays dominant role in each combustion case.

Table 1. The first two principal components values and sum of them for different types of waste incineration facilities

| | PC1 | PC2 | Sum |
|---|---|---|---|
| Hospital | 65.37% | 15.53% | 80.90% |
| Hazardous/Chemical | 52.71% | 19.81% | 72.51% |
| Municipal | 66.69% | 14.99% | 81.69% |

*3.2 Toxic PCDD/F isomer patterns and I-TEQ contributions*

The concentrations of toxic PCDF isomers are higher than respective toxic PCDD isomers with the same chlorine atoms, though OCDD is found to be the most abundant compound in average. The concentration variation of OCDD and OCDF is the largest, follow by 2,3,7,8-TCDD and 1,2,3,4,6,7,8-HpCDF. I-TEQ contributions of PCDF isomers are also lager than that of respective PCDD (Figure 1A). Though OCDD and OCDF are the most abundant isomers in concentration, both of them give the almost the least I-TEQ contributions because of their lowest I-TEF values. Due to the relatively higher I-TEF values and higher concentrations, 2,3,7,8-TCDF and 2,3,4,7,8-PeCDF present the greatest contributions to I-TEQ, followed by 2,3,7,8-TCDD, 1,2,3,7,8,9-HxCDF and 2,3,4,6,7,8-HxCDF (Figure 1B).

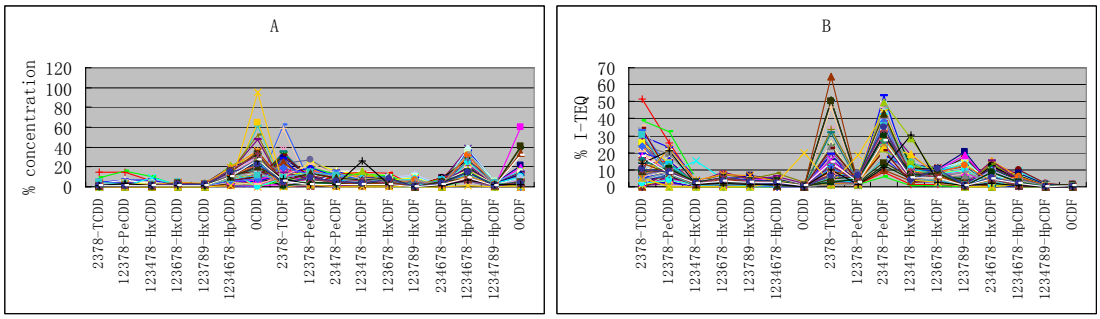


Figure 1. Concentration percentage of each toxic PCDD/F isomer (A) and I-TEQ contribution of them (B) for all the analyzed cases.

*3.3 Correlation analysis of toxic PCDD/F congeners and I-TEQ*

Though different formation mechanism plays dominant role in respective incineration facilities and the concentrations and I-TEQ contributions of each isomer are varied in great extent between different sampling cases, the correlation relationships of toxic PCDD/F isomers and I-TEQ are similar for either type of waste incineration facilities (Figure 2A). Amongst all the PCDD/F congeners, 2,3,4,7,8-PeCDF gives the strongest correlation relationship with I-TEQ, followed by 1,2,3,4,7,8-HxCDF and 1,2,3,6,7,8-HxCDF. However, the most toxic 2,3,7,8-TCDD have no significant relationship with I-TEQ (Figure 2B).

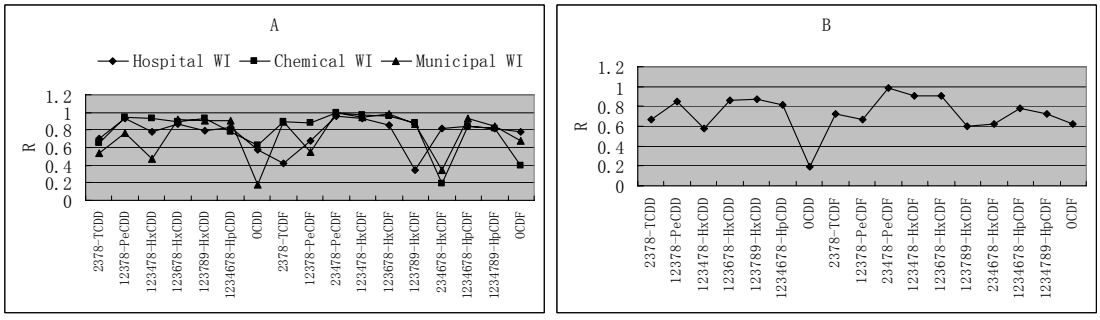


Figure 2. Correlation relationship of each toxic PCDD/F isomers and I-TEQ for different types of waste incineration facilities (A) and the same relationship for all the cases (B).

## 4. Conclusions

Principal component analysis reveals that there is no one common combustion isomer patterns for different types of waste incineration facilities and suggests that varied formation mechanism plays dominant role in each combustion case. OCDD and OCDF are the most abundant isomers but their I-TEQ contributions are least for their lowest I-TEF values. Due to their relatively higher I-TEF values and higher concentrations, 2,3,7,8-TCDF and 2,3,4,7,8-PeCDF present the greatest contributions to I-TEQ. The correlation relationships of toxic PCDD/F isomers and I-TEQ amongst different types of incineration facilities are similar. 2,3,4,7,8-PeCDF give the strongest correlation relationship with I-TEQ but the most toxic 2,3,7,8-TCDD have no significant relationship with I-TEQ.

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