Emissions of PCDD/Fs from 1960 to 2014 in China

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Abstract

Persistent organic pollutants (POPs) are groups of pollutants widely concerned as they are semi-volatile, bioaccumulative, persistent and toxic. Unlike other POPs, Polychlorinated-p-dibenzodioxins and dibenzofurans (PCDD/Fs) are not intentionally produced. They are generated during fuel combustion or as byproducts during industrial processes. Emission estimation of PCDD/Fs helps in understanding their major sources and taking measures to control them. Previous studies have reported PCDD/Fs emissions for some years and for some sources like iron&steel industry, however, information about long term historical PCDD/Fs emissions is still scarce. In this study, PCDD/Fs emissions for 86 sources from 1960 to 2014 were estimated. The PCDD/Fs emissions increased from 2798 g in 1960 to 7331 g in 2014 with cement production, iron&steel industry and waste burning as the 3 largest sources contributed more than half of the total emissions.

Methodology

Emission estimation:

Annual country-level emissions were calculated using the bottom-up method based on following equation:

$$Emis = \sum_i A_i \times EF_i$$

where i represents the emission source type, and A_i and EF_i represent the corresponding emission activity intensity and emission factor for source i.

Emission sources:

A total of 91 emission sources were considered. 80 sources were the first 80 sources of PKU-FUEL inventory (Wang et al., 2012) (details could be found on http://inventory.pku.edu.cn/). The other 11 sources were production of asphalt, PVC, pulp&paper, tiles, vinyl chloride monomer, second production of zinc, copper, lead and aluminum, cigarette smoking and cremation of corpses.

Emission factors:

256 emission factors were collected from literatures. For coal combusted in power&heating plants and industrial boiler and production of industrial products, we applied dynamic emission factors (EFs) using technology splits method (Huang et al., 2014) based on S-shape curve with following equation:

$$X_t = \left[\left(X_0 - X_f\right) \times e^{-\frac{(t-t_0)^2}{2\times s^2}} + X_f\right] \times \left(1 - X_{Advanced,t}\right)$$

where X_0 and X_f are initial and final fractions of a certain technology division, respectively; t_0 is the start time of the technology transition, and s is a rate; $X_{advanced,t}$ is the fraction of all advanced technology in time t. The EF for given sources i could be estimated with following equation:

$$EF_{i,t} = \sum_j X_{j,t} \times EF_j$$

where j represents the specific splitting technology utilized in emission source i, EF_j represents the EF for the specific source i with technology j, and $X_{j,t}$ represents the fraction of technology j used in emission source i.

Spatial Allocation:

Province level activity data were collected and used as surrogated to allocate national emissions to each province. Emissions from each province were further allocated to 0.1°× 0.1° using gridded fuel consumption data from PKU-FUEL for sources included in PKU-FUEL, or using industrial coal from PKU-FUEL for other industrial sources that were not included in PKU-FUEL, or using gridded population data (https://landscan.ornl.gov/).

Main results

1. Spatial distribution of the emissions for 2014: higher emission density for southeast part of China, but higher emissions per person for northwest part of China.

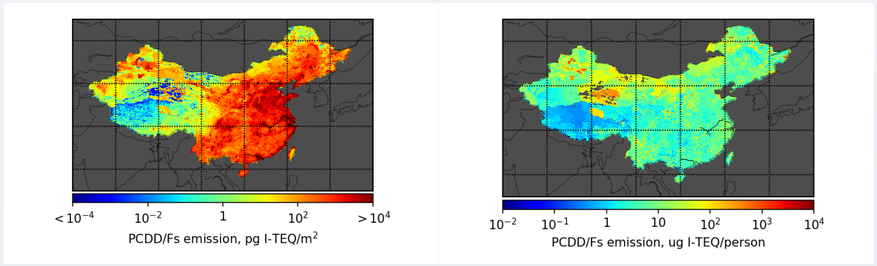

Figure 1. Spatial distribution of PCDD/Fs emissions per unit of area (left) and per person (right).

2. Historical emissions: large contribution from cement production and significant increasing contribution from waste burning.

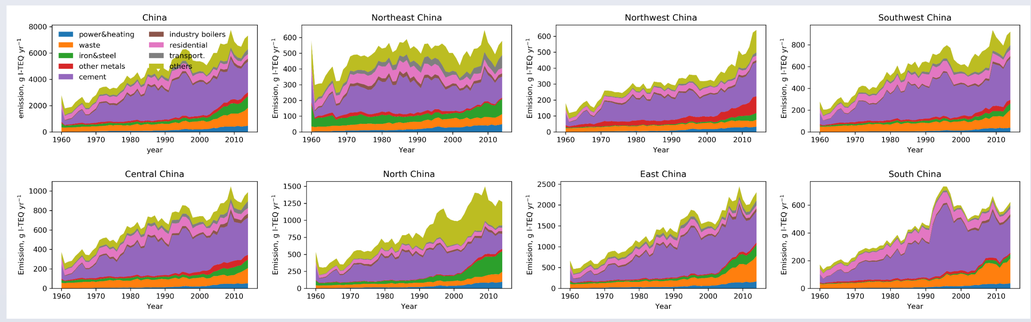

Figure 2. Changes of emission profiles from 1960 to 2014 for China and 7 Chinese regions.

3. Increased PCDD/Fs emissions per capita for all regions except Northeast China where PCDD/Fs emissions were not significant increased since year around 1970 as the result of decreased cement production; Emissions per unit of GDP were all decreased as a result of decreased emission factors for power&heating plants and industrial sector.

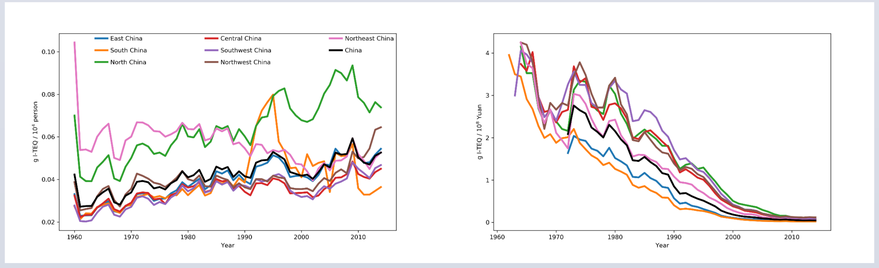

Figure 3. Changes of emission per person (left) and per unit of GDP (right) from 1960 to 2014 for China and 7 Chinese regions.

References

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