NATIONAL AND REGIONAL DIOXIN AND FURAN INVENTORIES

Heidelore Fiedler *

University of Bayreuth, Ecological Chemistry and Geochemistry, D-95440 Bayreuth, Germany

Introduction

In its decision 19/13 C of February 7, 1997, the Governing Council of the United Nation's Environment Programme (UNEP) requested the Executive Director of UNEP to prepare an international legally binding instrument for implementing international action on twelve specified POPs and to develop science-based criteria and a procedure for identifying additional POPs as candidates for future international action. With this mandate to facilitate a convention on reduction and elimination of releases of POPs, UNEP Chemicals will "…assist countries in the identification of national sources of dioxin/furan releases by promoting access to the information on available sources of dioxins/furans…". This paper summarizes initial findings obtained from national inventories of releases of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/PCDF) [1].

Materials and Methods

The data on emissions of PCDD/PCDF are based on a multitude of sources which is also reflected in the depth of the information available: full reports with in-depth information on generation of data and aggregation, scientific literature, homepages of governments and agencies, UNEP Chemicals' questionnaires, and personal communications. All emission data are reported in International Toxicity Equivalents (TEQ) and the releases given in grams TEQ per year.

Results

Most countries have estimated PCDD/PCDF emissions to air and only a few findings are available for emissions to water and soil or with products.

Today's major emissions of PCDD/PCDF into the environment come from combustion processes. Based on the presently available data and a reference year around 1995, the central estimate of total annual PCDD/PCDF emissions is approximately 10,500 g I-TEQ. The lower estimate is around 8,300 g I-TEQ/a and the upper estimate approximately 36,000 g I-TEQ/a. The high PCDD/PCDF emissions reported by a few countries for the early 1990s mainly drive these numbers. It should be noted that Japan has updated its dioxin inventory; for the year 1998, a total emission of 5,300 g I-TEQ was estimated. This new number will add another 1,300 g I-TEQ to

* Present address: UNEP Chemicals, 11-13 chemin des Anémones, CH-1219 Châtelaine, Switzerland

the "global" inventory. A summary of all PCDD/PCDF emissions to air for a year around 1995 is shown in Figure 1.

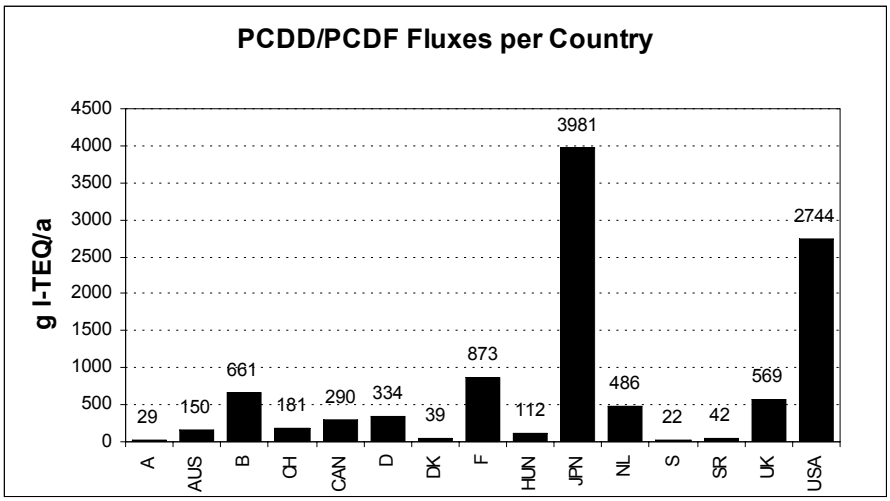

Figure 1: PCDD/PCDF emissions to air by country; reference year around 1995 [1]
A Austria, AUS Australia, B Belgium, CH Switzerland, CAN Canada
D Germany, DK Denmark, F France, HUN Hungary, JPN Japan
NL The Netherlands, S Sweden, SR Slovak Republic, UK United Kingdom
USA United States of America

From the information available for the year 1995, the sector of waste incineration (including municipal solid waste, hazardous waste, hospital waste, sewage sludge, waste wood, and crematoria) was still the major emitter in many countries. For the "global" inventory based on these fifteen countries the share of the waste incineration is almost 50 %. In absolute numbers, almost 40 % of the global PCDD/PCDF emissions was due to the municipal waste incinerators located in Japan.

Further information is from South Korea, which estimates total annual air emissions from municipal waste incinerators to 10.81 g I-TEQ and emissions with fly ashes to 127 g I-TEQ for the reference year 1997 [2].

Responses to UNEP Chemicals' questionnaires sent to countries in 1997, found 43 countries to be addressing dioxins and furans. Although most countries are aware that there might exist sources of PCDD/PCDF, only three countries provided additional quantitative data (Table 1). Croatia used emission factors from outside the country and estimates annual emissions of approximately 96 g TEQ per year from six major sectors with 97 % being from wood combustion. Finland reported between 100 and 200 g TEQ per year with waste incineration, sintering processes, steel industry and wood combustion as the major sources. Norway quantified a few sources, which gave 9 g TEQ per year: of these, municipal solid waste incineration and production of aluminum and magnesium contribute 4.4 g TEQ/a each.

Table 1: PCDD/PCDF emissions to air reported to UNEP Chemicals

	Annual Emission (g TEQ/a)
Croatia	95.5
Finland	98.3-198
Norway	9.15

The numbers in Figure 1 can be compared with an inventory established for the Member States of the European Union and an inventory established by TNO which both cover broader geographical areas. The EU report covers 17 countries and estimates approximately 5,800 g I-TEQ/a to be emitted from known sources (with an upper estimate of 20,000 g I-TEQ/a) [3]. The TNO study is less specific to PCDD/PCDF sources and estimates an annual release of 1,300 g I-TEQ for the reference year 1990 [4]. Finally, based on relatively few assumptions and no detailed evaluation of emission inventories, Brzuzy and Hites estimate a global PCDD/PCDF release of 50,000 g I-TEQ/a [5].

Conclusions

The present number of national PCDD/PCDF emission inventories is very small. Almost exclusively, the existing inventories only address PCD/PCDF emissions to air. For some sources, there are no emission factors determined, *e.g.* open garbage burning, landfill fires, *etc.* There may be considerable amounts of PCDD/PCDF being contained in reservoirs containing "old" chemicals such as 2,4,5-trichlorophenoxy acetic acid (2,4,5-T), pentachlorophenol used for wood treatment, polychlorinated biphenyls (PCB) used in transformers and capacitors. Other reservoirs include landfills/dumps, contaminated soils, and sediments.

Most data is available for countries from Western Europe and Northern America. From Asia, there is only one inventory for Japan and the estimate for emissions from waste incinerators from South Korea. From the southern hemisphere, only Australia has estimated annual emissions based on emission factors from the literature. From Africa, Central and Southern America, there are no data at all.

Amongst the source sectors, the best coverage exists for municipal solid waste incineration. As this sector undergoes the most dramatic changes in technology, emission factors and PCDD/PCDF emissions change rapidly: strong downward trends were recognized in countries with modern technology or rigid legislation. There is only limited information available from the iron and steel-producing sector. Some European countries have identified this sector as the major contributor to national dioxin inventories. The United States and Canada are aware of these sources, but so far, no measurements were performed. Here, generation of reliable data is urgently required.

From the few examples on PCDD/PCDF emissions to water and land or with products it can be concluded that emissions to water only cover wastewaters from the pulp and paper industry. Contamination in products largely is limited to pentachlorophenol (PCP); in most cases the PCDF in polychlorinated biphenyls (PCB) are being ignored.

Presently there exist no harmonized methods on generating and evaluating data for national PCDD/PCDF inventories: the coverage of sources varies from country to country. Some countries give ranges of lower and upper estimates whereas other countries use mean/median values. Harmonization of data acquisition and evaluation is an obvious need and would help in comparing national dioxin and furan inventories. Finally, harmonization of protocols for sampling stack emissions, water, soil, *etc.* and for analyzing these samples is highly recommended.

The present evaluation should only be seen as a snapshot on PCDD/PCDF emissions and estimates of total releases of these compounds into the environment. The major sectors of PCDD/PCDF releases into the air seem to be identified. Nevertheless, PCDD/PCDF sources may exist which have not yet been identified or quantified, especially in geographic areas with no data. For developing countries, PCDD/PCDF have not been quantified so far. The major reason is lack of financial or analytical capacities. It has to be taken in mind that emission factors established in industrialized countries cannot be assumed to be representative for industries in less developed countries.

Presently, the coverage is not sufficient to estimate global emissions of PCDD/PCDF. There are several efforts underway to identify dioxin sources in parts of the world where so far, there is no information available. Existing inventories will be updated, as it is obvious that measures were taken countries to reduce emissions of PCDD/PCDF. For some industrialized countries in Europe and North America, strong downward trends have been observed during the last years. Implementation of dioxin abatement technologies in industrial sectors and advanced combustion technology will help to reinforce such trends.

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References

(1) H. Fiedler (1999): Dioxin and Furan Inventories - National and Regional Emissions of PCDD/PCDF. Report by UNEP Chemicals, Geneva, Switzerland. May 1999
(2) Y.-S. Chang, J.-E. Oh, and D.-C. Sin (1998): The Evaluation of Emission and Environmental Levels of PCDD/Fs in Korea. Organohalogen Compd. **36**, 11-15
(3) LUA (1997): Identification of Relevant Industrial Sources of Dioxins and Furans in Europe. Materialien No. **43**. Landesumweltamt Nordrhein-Westfalen, Essen, 1997
(4) UBA (1997): The European Atmospheric Emission Inventory of Heavy Metals and Persistent Organic Pollutants for 1990. TNO Institute of Environmental Sciences, Energy and Process Innovation. Forschungsbericht 104 02 672/03 im Auftrag des Umweltbundesamtes Berlin, June 1997
(5) L.P. Brzuzy L.P. and R.A Hites (1996): Global Mass Balance for Polychlorinated Dibenzo-*p*-dioxins and Dibenzofurans. Environ. Sci. Technol. **30**, 1791-1804