Persistent Organic Pollutants (POPs)

How to Deal with Persistent Organic Pollutants (POPs)?

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The international negotiations (see Johannesburg, South Africa, December 2000 and Stockholm, Sweden, May 2001) about an 'International, Legally Binding Instrument for Implementing International Action on Certain Persistent Organic Pollutants' stimulated new interest in the environmental behavior of POPs and semivolatile chemicals in general, and also in the assessment procedures for such chemicals (reaching from scientific criteria to legal instruments). For these reasons, a series of articles with three main topics started in UWSF – Z. Umweltchem. Ökotox. and ESPR – Environ. Sci. & Pollut. Res.: (i) the international negotiations (Ed. K.-G. Steinhäuser), (ii) the application of the precautionary principle and socio-economic questions connected with the POPs convention (Ed. H. Hulpke), and (iii) scientific questions about the environmental behavior of POPs (Ed. M. Scheringer). The series began with an opening paper by W. Klöpffer and M. Scheringer in UWSF – Z. Umweltchem. Ökotox. 12 (6) 307-309 (2000), continued with four articles in UWSF No. 1–4 published to date in 2001, and will proceed with various contributions to the three topics appearing throughout the next two or three years either in UWSF (in German) or in ESPR (in English). An extended summary of each article will be published in the other respective journal. The summary of the opening paper was published in ESPR No. 1, 2001 (p. 63). Summaries of subsequent articles can be seen here.

Summaries

Global Treaty for the Regulation of POPs: The Stockholm Convention

(Globaler Vertrag zur Regelung von POPs: Die Stockholm Konvention)

[UWSF – Z Umweltchem Ökotox **13** (1) 39-44 (2001)]

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The success of the negotiations on the POPs Convention – after the failure of the negotiations over the climate protocol in The Hague – in late November (Johannesburg, South Africa, 4 to 10 November 2000) is an important result for international action to protect the earth from damage by chemicals. It shows the countries' real commitment to find compromises for protection of the environment and human health and for the restoration of damaged ecosystems on our planet. It deserves to be highlighted that all participants – not only the industrialized countries but also developing countries as well as environmental organizations and the (chemical) industry – regard the conclusion of this convention as a success and that a broad basis for joint action has thus been created. The convention is a signal also because of its useful contents, which includes instruments for the total elimination of 12 POPs in the beginning and of further persistent organic pollutants at a later stage. The basis for a gradual reduction of the increasing pollution of the environment on a global scale is given by mechanisms for subjecting further POPs to the requirements of this Convention in the future.

Existing Dioxin Inventories Worldwide and a New Methodology to Establish Comparable and Complete Release Inventories

(Existierende Dioxininventare weltweit und neue Methodik zur Erstellung von vergleichbaren und vollständigen Emissionsinventaren)

[UWSF – Z Umweltchem Ökotox **13** (2) 88-94 (2001)]

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Four years after Decision 19/13 C of 7 February 1997 of the Governing Council of the United Nations Environment Programme (UNEP), the Stockholm Convention on POPs (persistent organic pollutants) has been signed by 91 countries and the European Commission on May 22-23, 2001. This Convention includes legally binding provisions on unintentionally produced POPs such as PCDD/PCDF. In order to assist countries to fulfill the obligations of the Convention, UNEP has published a compilation of existing PCDD/PCDD release inventories (UNEP 1999) and is updating such information. The present status is as follows:

PCDD/PCDF are byproducts from chemical, industrial processes, almost all combustion processes and to a lesser extent from natural processes. They can occur in all release vectors: emissions to air, to water, to land, with residues and in products. So far, emission inventories published by countries are either based on nationally measured data or by application of emission factors obtained from other countries. Commonly, results were reported as toxic equivalents (TEQ). The evaluation of presently available inventories showed that the results are biased: whereas the metal producing and recycling industry is the sector with the highest PCDD/PCDF emissions in Europe, waste incineration is considered to be the major source in many other countries. Most countries report emissions to air only and do not consider the other release vectors. A further complication is that inventories do not have the same reference year. All this together makes it very difficult to compare PCDD/PCDF release inventories.

According to most recent data, 12,900 g TEQ of PCDD/PCDF are emitted into the atmosphere by 16 countries. Highest emissions are from the densely populated industrialized countries of the Northern hemisphere – Japan (6,300 g TEQ/a in 1997) and the United States of America (2,888 g I-TEQ/a in 1995). Measures to reduce dioxin emissions have resulted in strong downward trends, as shown, e.g., in Germany (down from 1,210 g TEQ in the years 1989/90 to 291 g I-TEQ in 1994/95 and an estimated <70 g TEQ for 1999/2000) and Japan (for 1999, the figure ranged 2260-2440). Nevertheless, potentials for further reduction have been identified.

Presently, Japan is the only country that reports PCD/PCDF emissions on the basis of WHO-TEQ, which include the coplanar and *mono-ortho* substituted PCB. According to the Japanese 1999 inventory the contribution from the dioxin-like PCB is between 11% and 36% of the total inventory.

So far, countries have utilized own methods to calculate their dioxin emissions and the majority has addressed releases to air only. The future Stockholm Convention on POPs will require to continuously reduce dioxin emissions. In order to assist countries in inventory making, UNEP has produced the Toolkit, a methodology to establish comparable dioxin inventories that address releases to air, water and land, with products and in residues.

Emission Inventories – Current State

(POPs – Stand der Entwicklung zur Emissionsinventarisierung)

[UWSF – Z Umweltchem Ökotox **13** (3) 165-170 (2001)]

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1 Scope and Background

The measures obliged to be implemented for reduction of the impact of POPs on the environment are essential elements in some international treaties concerned with these group of substances. Recently the Stockholm Convention was signed as a legally binding instrument for action against POPs on a global scale but some other international fora address these substances too, although in specific media, for instance in relation to their long-range transboundary atmospheric pollution (UNECE protocol) or their discharge

into the sea (HELCOM, OSPAR). All together, they are connected to reporting obligations, which should ensure the control of POPs impacts into the environment as a whole and evaluate whether of not the implementation of measures leads to the effects anticipated before. An essential element of these reporting obligations involves the collection and evaluation of emission data from the relevant sources within emission inventories. A summary of the current status of emission inventories for POPs with a special focus on atmospheric emissions summarised under EMEP provides a comprehensive figure as to how far emission inventories for POPs have currently been developed.

2 Highlights

Basic reports for European atmospheric emission inventories were presented by Berdowsky et al. [1] in 1997 and by Pacyna et al. [2,6] in 1999. Especially the evaluations from Pacyna have shown the basic problems for the quantification of specific POP emissions.

Now there are considerable uncertainties of reported emission data by the countries and in expert evaluations referred to marine and atmospheric impacts. Harmonised instruments for emission evaluation are needed and under development in the form of guidance documents for the marine environment 'Harmonised Quantification and Reporting Procedures for Hazardous Substances' (HARP-HAZ) [4] and under EMEP in the 'Atmospheric Emission Inventory Guidebook for UNECE/LRTAP' [5].

Problems and reasons for uncertainties in quantification of environmental impacts can be explained by some examples: lindane (hexachlorocyclohexan, HCH), polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH) und hexachlorobenzene (HCB).

3 Results

Lindane: Quantification of environmental impacts includes high uncertainties because of the fact, that lindane was used as an insecticide in a wide range of products in the past. There are rare data, how much of these products was produced with which of the different existing lindane formulations and where these products were applied.

PCB: The uncertainties in evaluation of PCB impacts are especially high in the field of open applications, where PCB was used in sealants or varnishes. Also the number of small capacitors and electrical devices containing PCB is difficult to count and the amount of these which are disposed of regularly is decisive for environmental emission, but rarely known. Data which shows the amounts of PCB emitted as an undesirable side-product formed in thermal processes are compared with those of dioxins and furans rarely available in all European countries. The last sentence is valid for HCB emitted as a side-product as well.

PAH: The evaluation of PAH impacts are demonstrated by the leading component benzo(a)pyrene in many source inventories. The wide spectrum of single PAH components is one reason why emission data are within wide ranges for the same source types in different inventories dependent on the measured congeners. Most PAH emissions are released from residential combustion followed by anode production plants and cokeries. The specific source type mainly responsible for emissions, in this case, is a reason for the wide setting of the limits between the margins. Contrary to cokeries and anode production plants, PAH emissions from residential combustion can not evaluated on the basis of the exact numbering of existing plants, but is released from a high number of very small and uncontinuously working installations. Data from a German [3] and a European inventory present the ranges of environmental impacts.

4 Conclusions

The data of emission inventories are at least as good as the evaluation of emission data which has been performed, and as the precision of basic assumptions and measurements. Models can help to simulate difficult source type conditions, especially in the case of more diffuse environmental impacts. Different concepts are under investigation. However, the need for harmonised methods and procedures based on a precisely working measurement network is a question which must be answered previously, especially in the case of POPs.

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Long-Range Transport of Persistent Pollutants in the Northern Hemisphere

(Schadstoff-Ferntransport in die Arktis)

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The Arctic is still considered as one of the few unpolluted regions in the world. This is true if one compares the Arctic region with middle latitude regions which are influenced more by human activities. However, the Arctic region is not isolated from all human impacts. In recent years, high concentrations of persistent pollutants (organic chemicals, metals) were detected in top predators of the Arctic food chain and indigenous peoples from the Canadian and Greenland Arctic, although no local contamination sources are known. The comprehensive, scientific investigations of the past 20 years confirmed that the combination of atmospheric and waterborne long-range transport is the major source of the high concentrations of persistent organic pollutants (POPs) in the pristine Arctic environment. However, also pelagic marine organisms (e.g. Atlantic cod, marine mammals) can transport large amounts of persistent pollutants in their lipids and introduce contaminants into the Arctic food web. Thus, the pollutants are transported into the Arctic and subsequently accumulated through the short and unbranched Arctic food web of the top predators. The most accepted theory nowadays describes the long-range transport of persistent pollutants as a combination of atmospheric and sea current transport, or as a 'global distillation' process. Depending on such physical properties of the substances as vapour pressure and the ambient temperature, persistent (semivolatile) contaminants are transported over different distances prior to deposition (sea surface, sediment, soil). After the deposition, however, and depending on the weather conditions and surrounding temperature, persistent pollutants will be re-evaporated into the atmosphere and undergo further atmospheric transport to the Arctic region. This process is also called the 'grasshopper effect'. The global transport of persistent pollutants into Arctic regions can be described as a repeatedly occurring combination of atmospheric and waterborne transport in which the main transport vehicle depends on the physical properties of the transported compound. The role of characteristic meteorological conditions in the respective climate zones through which the contaminant is transported must not be underestimated. Strong seasonal differences in temperature and precipitation rule the global weather situation. Therefore, seasonal pattern differences occur for the distribution of some persistent pollutants in the Arctic environment depending on average temperature, main wind and sea current directions, humidity and daytime light conditions (causing photochemical degradation).

The consumption of traditionally hunted marine mammals (seals, whales) was identified as one of the main reasons for high contamination burdens in the Canadian and Greenland Inuit populations. Consequences and counter measures against high contamination loads in the Arctic human populations and ecosystems are currently under discussion. However, no comprehensive measures concerning restrictions of hunting traditions are taken by the respective governments to date due to the primary social consequences which are to be expected. The advising experts argue that such a restriction would destroy the original social structures of the Inuit populations. Therefore, the drawbacks of such a hunting restriction would weigh heavier than the expected positive effects of the reduction of contaminant burdens ('Arctic dilemma').

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Persistent Organic Pollutants in the Southern Hemisphere
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Biomagnification of Hexachlorobenzene: Influence of Uptake Routes in a Laboratory Test
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Tributyltin on its Way to the 'Top of the POPs'?
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