Mass Flows of Organohalogen Contaminants in Wastes in the European Union

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Introduction

In 2004 the European Commission (DG Environment) launched a project to provide background information and a decision basis for the definition of limit values for 14 POP substances and substance classes in waste as foreseen by 2005 in the European Regulation on persistent organic pollutants (2004/850/EC). This regulation entered into force in May 2004 to implement the provisions set up in the Stockholm Convention and will, besides other, define concentration limits for 14 POPs above which the POPs content in waste shall be subject to destruction or irreversible transformation. Against this background it was a major objective of the project
to compile and evaluate existing data on occurrence and levels of POPs in different waste categories, establish mass flows for POPs and wastes and assess the relative importance of the waste sector in relation to the overall flow of these pollutants into the environment.

Materials and Methods

The results of the project had to enable a number of conclusions:

- comparison of the path "emission" to the path "waste"
- comparison of the importance of the various POPs
- comparison of the importance of various industrial and domestic sectors
- comparison of different handling and disposal options
- relative coverage of wastes and pollutant by different POP limit values
- allow to establish scenarios on the consequences of different limit values
- provide a basis for a prognosis of future developments.

furthermore the methodology had to be flexible to allow inclusion of new data and update the established data base in order refine/precisise conclusions and future prognosis with increased knowledge.
Following these different purposes the mass flows have been calculated by means of a computer based system. As input parameters we used activity data, waste generation factors and specific contamination data for emissions and solid residues in the 25 EU Member States as far as accessible in international data bases (Eurostat, IEA, EEA, EMEP, national statistics) and literature (BREF documents, UNEP documents on BAT/BEP with respect to POPs) plus unpublished data directly communicated by industry associations, scientific experts or NGOs. [1,2,3,4,5]
Based on these data we calculated figures on annual generation of divers residues and annual discharge of specific POPs from important sectors on EU 25 and Member State level. Overall mass flows indicating the relative importance of annual discharges to wastes in relation to air emissions and environmental loads have been established on EU 25 level. In order to give an overview on the situation in EU 25 the calculation is based on mean values but ranges and Member State specific values are available in the report. Due to limited data it was not possible to derive medians, extrapollations on per capita basis had to be used in a number of cases and uncertainty is not neglectable. Nevertheless the results for the first time provide an overview on the dimension and distribution of POP contamination in waste and give a scientific base to the discussion on feasible limits for POP waste in Europe and under the Stockholm Convention.

Results and Discussion

PCDD/F quantities and concentrations

Investigated mass flows of PCDD/F amount to a dimension of 21 kg PCDD/F-TEQ/year in EU 25. The dioxin flow is characterised by relatively small amounts which are constantly formed and discharged while remarkable stocks awaiting elimination do not exist. With about 4 kg PCDD/F-TEQ/year air emissions account for only 20% of the overall discharge from investigated anthropogenic sources, while 80% (17 kg PCDD/F-TEQ) is contained in wastes and other residues. Therefore, the waste sector, which divides into waste disposal operations (63% of the total discharge/year) and recycling and recovery (16% of the total discharge/year) is of considerable importance for the overall flow. Compared to an calculated minimum environmental load of 200 kg PCDD/F-TEQ the waste sector would add a significant amount ~7% per year. So further regulation on PCDD/F in the waste sector seems to be important. However the major share of PCDD/Fs discharge via waste is due to high volume but low contaminated wastes – mainly MSW, but also bottom ashes, slags, sewage sludge and compost.

Thus only a small part of the overall PCDD/F-TEQ discharge of about 22% may reasonably be influenced by the POP regulation.

On the European scale the share of PCDD/F-TEQ directed to landfill is high in comparison to other pathways and much of it is non-hazardous waste landfill due to the high contribution of municipal solid waste (MSW), which alone contributes with almost 7 kg PCDD/F TEQ/year to the total discharge. Only about 2 kg PCDD/F TEQ/year is directed towards hazardous waste landfill and underground storage due to large amounts of contaminated filter ashes from waste incineration. The almost 2 kg/year which can not be allocate to either hazardous and non-hazardous waste landfill include PCDD/Fs from sinter plants, EAFs, iron smelting and biomass power plants, thus including higher and lower contaminated wastes.

3.3 kg PCDD/F-TEQ/year are contained in wastes that are recycled or recovered in secondary processes. These processes however are also dominated by low contaminated ashes from power production (almost 2 kg/year) and other low contaminated wastes such as compost and sewage sludge and bottom ashes from incineration. Residues from metallurgical processes, which are reused in secondary thermal processes for metal recovery contribute only 0.8 kg PCDD/F-TEQ/year which in addition is further reduced in the processes.

In detail overall air emissions of PCDD/Fs in EU25 are dominated by domestic combustion of coal and derivatives and other non-industrial sources (about 3 kg PCDD/F TEQ/y), when BAT standards are applied in industrial processes. Most important sectors for discharge of PCDD/F via residues are municipal solid waste (35%), municipal solid waste incineration (16.5%), power production (18.6%) and the ferrous metal industry with electric arc furnaces (10.3%) and sinter plants (8.4%).

Average concentrations of PCDD/F-TEQ in bottom ashes, slags, compost, sewage sludge and MSW are in a range below 0.05 ppb and as such comparable with or only one order of magnitude higher than levels that are currently detected in European soils. In a second group (e.g. APC residues, metallic dusts) contamination levels in average range from 0.5-5 ppb and are thus 1-2 orders of magnitude higher than environmental levels in soils.

PCB quantities and concentrations

Investigated mass flows of PCBs in EU25 accounts to about 6,250 t/year which is significantly higher than the PCDD/F discharge. The overall PCB flow is still characterised by remarkable stocks awaiting elimination. Compared to this formation in combustion processes and discharge to solid residues is not important. PCBs enter the waste regime mainly via long-lasting products and construction material reaching its waste stage. Besides this they are contained in waste oils, shredder non-metallic fraction and shredder dusts, waste wood, combustion residues, municipal solid waste, sewage sludge and compost.

With an estimated total of about 1000 t/y air emissions of PCBs account for less than 15% of the overall discharge from investigated anthropogenic sources, while >85% (about 5,600 t/y) is contained in wastes and other residues. Therefore, the waste sector is of considerable importance for the overall flow. At EU25 scale PCB discharge via the waste sector is clearly dominated by disposal operations (almost 90% of the total discharge/year) while recycling and recovery is low (2‰ of the total discharge/year). The relation changes in countries where large PCB containing equipment (transformers, capacitors) has already been discarded of. Compared to a calculated minimum environmental load of 200,000 t PCB already emitted to the environment the waste sector would add (~3% per year).. The major share of PCB discharge via waste is due to high contaminated wastes – mainly large electric and electronical equipment and construction and demolition waste exceeding the limits for "PCB waste". Thus the major part of the overall PCB discharge (about 80%) is already subject to strict disposal regulation under the PCB Directive. So further regulation on PCBs in the waste sector does not seem to be of major important until stocks of highly contaminated equipment has been disposed of by 2010 and highly contaminated construction material is eliminated from buildings.

Total PCB concentrations in a first group of wastes i.e. ashes, sewage sludge, compost and municipal solid waste range from 0.01-0.6 ppm. This is comparable or only moderately (1 order of magnitude) above levels observed in the soil compartment in Europe. In a second group of waste types including e.g. waste oil, shredder residues from end-of-life vehicles and white goods, levels in in most cases are below10 ppm. For the plastic fraction of cable shredding and for ashes from domestic burning levels range from 10-30 ppm and are thus 2-3 order of magnitude higher than background concentrations observed in the environment. In a last group, which consists of C&D waste and PCB containing equipment concentration levels easily exceed 50 ppm and can reach concentrations of several thousands of ppm.

POP pesticide quantities and concentrations

POP pesticides (Aldrin, Dieldrin, Endrin, Chlordane, DDT, Heptachlor, Chlordecone, Mirex, Toxaphene) have been largely produced and used as insecticides for crop and wood protection and stockpiles are still existing in a number of EU Member States. In addition there is ongoing production of DDT which is mainly used as precursor for Dicofol. Consequently two mass flows have to be distinguished for POP pesticides. However as production of DDT and use of Dicofol is not yet related to the waste regime only the reduction of stockpiles has currently to be considered. Provided a constant reduction over a period of ten years (2000-2010), this sector has a dimension of 537 t/year of highly contaminated material. In addition un unknown quantiy of POP pesticides is contained in contaminated soils and construction material entering the waste regime via construction and demolition waste.

With an estimated total of about 5 t/y air emissions of POP pesticides account for hardly 1% of the overall discharge from investigated anthropogenic sources, while >95% (about 500 t/y) is contained in wastes and other residues. Therefore, the waste sector is of considerable importance for the overall flow. At EU25 scale management of POP pesticide discharge via the waste sector is clearly dominated by destruction methods (>95% of the total discharge/year) while landfill and recovery is low. It has however to be taken into account, that contaminated soil and C&D waste has not been included into the calculation due to an insufficient data base. Compared to a calculated environmental load of 100,000 t PCB already emitted to the environment the waste sector would add (~0.5% per year). The major share of POP pesticide discharge via waste is due to high contaminated wastes and will thus be covered by limit values under the Stockholm Convention and the POP regulation.

Other POP quantities and concentrations

Hexachlorobenzene (HCB) and γ-HCH (Lindane) are still produced with an estimated volume of more than 1,000 t/year. In addition HCH (Lindane) enters the waste regime via stockpiles from former production and contaminated storage or production sites. HCB is furthermore contained in flue gas treatment residues from thermal processes and waste water treatment residues from chemical processes. However compared to discharge from remaining stocks the importance of these sources is quite low.

Hexabrominated Biphenyl (HxBB) was used as flame retardant in thermoplastics for electric isolation in cars and electronic devices up to the nineties. Due to the longevity of these products, stocks in a dimension of 3,500 t/year can be expected in the plastic fraction of shredder residues.

With an estimated total of about 100 t/y air emissions of other POPs account about 3% of the overall discharge from investigated anthropogenic sources, while >95% (about 3,500 t/y) is contained in wastes and other residues. Therefore, the waste sector is of considerable importance for the overall flow. At EU25 scale management other POP discharge via the waste sector is clearly dominated by landfilling (almost 80% of the total discharge/year) while destruction and recovery is relatively low (~20% of the total discharge/year). It has however to be taken into account, that contaminated soil and C&D waste has not been included into the calculation due to an insufficient data base. Compared to a calculated environmental load of 500,000 t other POPs (largely HCH) already emitted to the environment the waste sector would add only ~0.7% per year. The major share of other POP discharge via waste is due to high contaminated wastes and will thus be covered by limit values under the Stockholm Convention and the POP regulation.

Scarce contamination data for POP pesticides and other POPs suggest either high contamination in obsolete products or soil and construction material from contaminated sites (up to several hundred ppm) or low levels in municipal solid waste in the range of environmental contamination (<0.1 ppm). It has however to be stated that the overall data base for contamination levels of POP pesticides and other POPs in waste matrices to date is not sufficient to draw final conclusions. There is no data on HxBB concentrations in shredder residues.

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