A REVIEW OF DIOXIN RELEASES TO LAND AND WATER IN THE UK

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Abstract

The Environment Agency implements UK government policy to control releases of pollutants, including polychlorinated dioxins (PCDD) and furans (PCDF), to air, water and land from potentially polluting processes in the UK. To assist this process the Agency requires information on the scale of such releases from industrial and non-industrial processes in the UK. This study was the first attempt to estimate releases of PCDD/F to land and water to complement the recently updated inventory of releases to air. Although the study was hampered by a lack of data, releases to land appear greater than releases to air or water. Most releases to land are in materials that are landfilled. Further study is needed to quantify releases from many processes.

Introduction

The UK government has adopted a policy of identifying and controlling the sources of some chlorinated organic compounds including polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF). While several studies have produced inventories of these emissions from industrial and non-industrial processes to air in the UK, this is the first study to attempt a comprehensive inventory of PCDD/F emissions to land and water. Commissioned by HMIP (now part of the Environment Agency), it complements the recent update of the inventory of UK PCDD/F emissions to air [1].

The specific objectives of the study were:

- To prepare an inventory of PCDD/F releases to land and water from industrial and non-industrial processes in the UK;
- To identify future trends for these releases and assess any inter-media effects of pollution controls now being imposed;
- To make recommendations based on the conclusions of the study.

This paper presents the outcomes of the study. If offers a first attempt at compiling an inventory, discusses the uncertainties stemming from the data gaps and other limitations on the work, and makes recommendations for providing more hard data on which action can be based.

It is important to stress that this is not a risk assessment study. The impact of discharges catalogued in the inventory will depend largely on whether humans or ecosystems are exposed to unacceptable concentrations of these compounds, and the potential for exposure depends, in turn, on the handling and treatment of the materials released. An assessment of exposure is outside the scope of this project and the figures given here cannot be used to indicate the relative risks from different sources.

Approach

Releases to land were defined as wastes sent to landfill, releases to the open environment and, in some cases, PCDD/F contained in products. The inclusion of releases to landfill accounts for the relatively high totals of estimated releases to land. Releases to water were defined as effluents discharged to controlled waters and releases to sewer.

The study concentrated on those processes which have the potential to *form* PCDD/F. However, some processes may lead to releases of PCDD/F not formed in the process but brought in with raw materials, as in the case of landfilling of household wastes for example. The potential for releases to have an adverse impact depends largely on the treatment and final destination of the materials in which they are contained and on the behaviour of PCDD/F in these environments. Where possible the study indicated the likely destination of these materials.

Industrial processes were divided into two broad categories:

- *Chemical processes*, in which reactions are generally in the liquid phase and at temperatures below 250^{0}C. Generally, the product is retained in the reaction vessels and PCDD/Fs, if formed, are more likely to be released to water and land than to atmosphere;

- *Thermal processes*, in which temperatures are typical of combustion-related processes (800^{0}C and above) but with the potential for some parts of the process train to be maintained at lower temperatures, particularly between 250^{0}C and 400^{0}C.

Processes were screened for inclusion in the study by applying criteria developed to assess their potential to form PCDD/F.[1)] Data was gathered on the quantities of solid and liquid materials released to land and water from these processes and the concentrations of PCDD/F in them. This was assessed for quality and applicability and then combined to give estimates of releases. Wherever possible, data from the UK was used, but where this was absent or incomplete it was supplemented by data from other countries. No field work was undertaken.

Inventory of PCDD/F Releases to Land and Water

The inventory produced as a result of the study is given in Table 1. Releases are expressed in grams of PCDD/F toxic equivalent (TEQ) per year, using the International Toxic Equivalent system. Some data from Scandinavia is given in Nordic TEQ: for the purposes of this study, this is taken as broadly equivalent to the International TEQ. In general, a range of estimated releases is given, with no attempt to define a central tendency. Since lack of data made releases to water much harder to quantify than releases to land, the study classified the *potential for* releases to water as High (above 1 g TEQ), Medium (0.1-1 g TEQ), Low (under 0.1 g TEQ) or Negligible (for those unlikely to produce any releases). Processes were assessed on the quantity of water discharged, the potential for contamination of any or all of this discharge, and the treatment, if any, prior to discharge.

Total quantified ***releases of PCDD/F to land*** were estimated at between 1500 g TEQ and 12,000 g TEQ per year. The largest contributors to the upper range estimate are the open use of chemicals, the manufacture of pesticides, incineration of MSW and accidental fires.

Although the study found insufficient data to generate a complete inventory of ***releases to water,*** the processes with greatest potential for releases appear to be the open use of chemicals, sewage treatment, disposal of waste oils, accidental fires, the production of pesticides and chlorophenols and chemical waste incineration. Run-off from roads may also be a significant source.

Although most discharges to land are placed in landfills and are therefore not releases to the open environment, wastes from some processes are applied to land, and this may increase the potential for human exposure. Landfills are widely accepted as secure containment systems, but there are many types of landfill in use with different combinations of wastes and pollution controls and the behaviour of PCDD/F may vary from landfill to landfill. More study is needed here. Also a fraction of the PCDD/F contained in solid waste disposed of to landfill may be discharged to the open environment through losses between the point of production and the point of disposal.

Estimates for releases from the open use of chemicals are based on the use of pentachlorophenol (PCP), largely entering the UK from abroad, and various pesticides. The PCDD/F in these will probably become a release to land on disposal and products treated with PCP many years ago are causing releases now. There is a lack of data for releases from chemical products, but some are less likely to be contaminated than in the past because of measures to limit their contamination.

There is also a lack of data for estimating releases from the manufacture of pesticides, but wastes from the production of a range of chlorinated pesticide formulations can contain PCDD/F. Whilst the bulk of these wastes is likely to be incinerated, this may not be true for all. Further study is needed here.

Residues from the incineration of MSW can lead to significant releases. In particular high concentrations may be expected in the fly ash from some old plants with electrostatic precipitators [2]. These releases are expected to fall with the closure or upgrading of old plants, but the resulting great reductions in emissions to air will mean that an increased proportion of the PCDD/F produced will be captured in the solid residues. This may also be the case for clinical waste incineration plants.

Releases from accidental fires may be significant but are difficult to estimate. More information is required on the quantities of materials involved and the levels of contamination found.

In addition, releases from the manufacture of per- and trichloroethylene may be significant, but these are disposed of in salt caverns under strict conditions [3]. Furthermore, major changes are being made to the manufacturing process and these are expected to lead to major reductions in the releases. The processing of scrap metals may also give substantial releases if it is not carried out under strictly controlled conditions, but there is a lack of UK data.

Future Trends

For the majority of processes, releases to land are likely to reduce. This is due to reductions in levels of contamination in products, in the formation of PCDD/F in many industrial processes, and in

quantities of solid and liquid wastes as a result of a landfill tax, waste minimisation, reuse/recycling etc.

However, improvements in the control of releases to air brought about by pollution control systems may lead to increased PCDD/F in some wastes, and thus to increased releases to land - for example, from clinical waste incineration. Changes in waste disposal routes, such as increased use of sewage sludge as a soil dressing, may also increase PCDD/F releases to land.

Releases of PCDD/F to water appear to be declining. Many water treatment systems seem to be effective in reducing concentrations in effluent streams by removing the solid material to which PCDD/F is attached.

Data Gaps / Limitations to the Study

There are several caveats that must be noted in relation to the estimates provided in this study.

- There is very little data on releases of PCDD/F to media other than air, either in the UK or overseas. The study has therefore had to draw in some cases on old, limited or incomplete data sets. More contemporary data is urgently needed to complete the inventory. The UK system of Integrated Pollution Control has the potential to improve knowledge about releases of PCDD/F to all media, but mechanisms for assembling and collating the large amounts of data generated under the regulations are not yet fully operational.

- Because PCDD/F form, and are present, in very small amounts, there may be processes other than those considered here which lead to the formation of these compounds.

- Because PCDD/F are resistant to degradation, bind tightly to solids and can be transported in the environment, some processes give rise to releases although the PCDD/F were not formed in the process. These have been identified where possible, since it is important to know which processes release PCDD/F, even if the PCDD/F is not actually formed in the process itself.

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Table 1. Estimated Releases to Land and Water

Process	Release to land, g TEQ/y	Potential release to water, (g TEQ/y)	Comments
Carbonisation	0.023-0.85	L (0.0044)	
Coal combustion	1.7-86	L	much ash is sold for processing
Domestic soot	0.16-30	negligible	
Wood combustion	0.67-20	negligible	
Straw combustion	0.20-10 '	negligible	
Tyre combustion	1.9-2.7	L	
Refuse derived fuel combustion	3.7-6.4	L/M	
Poultry litter combustion	0.26	negligible	
Petroleum processes	not quantified	L	
Sinter plants	0.020-0.060	negligible	
Electric arc furnaces	59	negligible	average PCDD/F data used
Primary aluminium	0.082	L	
Secondary aluminium	29-230	L/M	
Secondary magnesium	0.38-3.2	L/M	based on PCDD/F data from aluminium processes
Secondary copper	24	L/M	
Secondary lead	95-220	L/M	
Cement	0.00040-12	L	
Lime	0.000060-1.8	L	
Other mineral processes	not quantified	M (<0.45)	data for asphalt mixing
Chlorine production	6.0	L	
PVC/EDC production	25-80	M (0.070-0.40)	
Per/tri chloroethylene production	350-630	M (0.070-0.40)	discharge to land goes to containment
Pesticides production	8.9-2000	H (0.0089-2.0)	very limited data
Chlorophenol production	not quantified	H	wastes usually incinerated, releases to water reducing
MSW incineration	520-2400	M	old plants to close or upgrade by Dec. 1996
Chemical waste incineration	0.0058-2.0	H (0.018-1.1)	
Clinical waste incineration	12-37	M	releases to land may increase
Sewage sludge incineration	0.98	L (0.0020)	
Paper and pulp processes	2.8-11	M	little UK data
Textile treatment	not quantified	M (0.032-0.93)	based on PCP usage only
Manufacture of dyes	not quantified	M	insufficient information
Timber treatment	0.011-0.32	L (0.0028-0.083)	based on PCP usage

Process	Release to land, g TEQ/y	Potential release to water, (g TEQ/y)	Comments
Accidental fires	7.5-2400	H (0.075-24)	
Sewage sludge disposal	14-56 [1]	H (0.41-1.6)	
Waste oil disposal	not quantified	H (0.28-1.2)	old data only
Bonfires and incidental fires	0.075-42	negligible	
Disposal of MSW to landfill	150	M (0.23-0.59)	mean contamination data, leachate may contain PCDD/F
Compost from MSW	1.7 [1]	L	
Dredging	29 [1]	not quantified	average data
Open use of PCP	100-3000 [1]	H	no data on other CPs
Use of other pesticides	4.8-240 [1]	H	little contemporary data
Surface run-off	not quantified	M	
Dry cleaning	0.68-9.8	L (0.000090)	
PCBs	0.31-0.38 [2]	M	no TEQ data
Total	**1500-12,000**		

Note:

1. Significant fractions of releases to land from these processes may not be to landfill (for other processes the bulk is landfilled).