PCDD/PCDF BALANCE OF DIFFERENT MUNICIPAL WASTE MANAGEMENT METHODS V: COMPARISON AND RESULTS

Barbara Zeschmar - Lahl, Michael Wilken, Johannes Jager
ITU-Forschung, Ansbacher Str. 5, D - 1000 Berlin 30, FRG

and

Uwe Lahl
Umweltdezernat Stadt Bielefeld, Neues Rathaus, D - 4800 Bielefeld 1, FRG

Introduction

Whenever a location for a waste treatment or removal facility is considered for suitability, or is selected, the release of pollutants is one of the main critical arguments in the political and public discussion. The real or potential emission of chlorinated dioxins and furans has meanwhile become one of the decisive criteria for the acceptance or, and that is nearly always the case, for the rejection of such decisions. In this paper, the PCDD/PCDF balance of different waste management is compared by some examples. Results given in toxicity equivalents (TE) refer to the calculation method of the Federal Bureau of Health (Bundesgesundheitsamt) in Berlin.

Discussion

One of the most important risks resulting from PCDD/PCDF-emissions out of waste removal facilities is the long-term accumulation of these compounds in the soil.

Municipal waste incineration is meanwhile today's synonyme for dioxins. Old and badly equipped MWI emit dioxins and furans up to 10 ng (TE)/m^3 , some very bad even more. Because this leads to a burden of the environment that cannot be tolerated in the long run, the federal authorities have restricted these emissions to 0,1 ng (TE)/m^3.
Referring to the examined municipal waste incinerator (MWI) Bielefeld - Herford with an average of 4,5 ng (TE)/m^3 PCDD/PCDF in clean gas, an accumulation in the soil of 42,74 ug (TE)/ha*a has to be expected, following a conservative assessment (full capacity all over the year, deposition velocity = 0,01 m/s, maximum effected area). Under the assumption of a half-life of 12 years for all isomers of PCDD/PCDF, maximum soil concentration (Cmax) will amount to 1,02 ng (TE)/kg (1). Taking into consideration a pre-burden of 1 ng and on the other hand other systemic parameters (e.g. longer half-life for several isomers) causing higher Cmax-values, there is high need for emission reduction for MWIs. Taking the calculation for the MWI Bielefeld-Herford, plants emitting less than 0,1 ng (TE)/m^3 will cause a Cmax of 0,023 ng (TE)/kg, which can be regarded as minor in comparison with the average pre-burden of 1 ng (TE)/kg (2).

A waste management method recently discussed to have nearly no dioxin problem is **landfill disposal**. Here, the mentioned substances are laid down for long times and may not or only in few amounts return into the environment. With regard to the average contents of dioxins and furans in the waste input, the annually arising 30 million tons of municipal waste contain about 500 to 1000 gram dioxins and furans, and a lot more of precursor substances like PCB, chlorophenols and chlorobenzenes, and other organochlorine compounds, too. But which is their fate in historic dimensions?
In addition, landfills release disposal gasses, which have to be caught. Their combustion should reasonably be combined with energy reuse. But because of the high content of precursor substances, dioxins and furans can be newly generated within disposal gas combustion. As our analyses show, exhaust gas after combustion of disposal gas can contain considerable amounts of dioxins and furans. We found 75 to 217 pg (TE)/m^3, other authors report maximum values up to nearly 1 ng (TE)/m^3 (2). With regard to these analyses, one can expect PCDD/PCDF-contamination of referring exhaust gas in the magnitude of 0,1 to 1 ng (TE)/m^3, while disposal gas itself seems to contain no measurable amounts of dioxins and furans.

Which would be the environmental input of dioxins and furans, if the entire amount of annually arising 30 million tons of waste were deposited in landfills and the released gas was burnt? We calculated several scenarios which are given in the following table. Following a to our opinion realistic calculation (scenario 2), the annual input would amount to more than 50 gram (TE) per year.

Tab. 2: Assessment of potential input of PCDD/PCDF via combustion of disposal gas
Assumption: The entire municipal waste (30 million t/a) is deposited in a landfill, and released disposal gas is burnt.
Scenario I: minimum Scenario II: realistic Scenario III: worst case

	Scenario I	Scenario II	Scenario III
Annual waste input	30 x 10^6 t	30 x 10^6 t	30 x 10^6 t
Release of disposal gas (aerobic/anaerobic)	5 x 10^9 m^3	15 x 10^9 m^3	45 x 10^9 m^3
Disposal gas vs. exhaust gas from incineration	1 : 6,5	1 : 8,5	1 : 10
Release of exhaust gas	32,5 x 10^9 m^3	127,5 x 10^9 m^3	450,0 x 10^9 m^3
Content of PCDD/PCDF	0,05 ng TE/m^3	0,5 ng TE/m^3	0,9 ng TE/m^3
Theoretical environmental input	1,62 gram	63,75 gram	405,0 gram

Another well-recommendend and senseful waste management method is composting of vegetable wastes. We analyzed several waste samples due to their contamination with dioxins and furans, and found most samples to lie in the range above 5 ng (TE)/kg. Taking a half-life of PCDD/PCDF of twelve years into account, e.g. the moderate spreading of compost (10 t/ha*a) with normal quality (about 18 ug (TE)/t) will suffice to reach the soil limit of 5 ng (TE)/kg, if the soil has a pre-burden of 1 ng (TE)/kg, which is usual for german soils contamination (3). A higher contaminated compost (136 ug (TE)/t, 10 t/ha) will cause a soil burden higher than allowed for any agricultural use (40 ng (TE)/kg) (see part III). If all vegetable wastes arising in the FRG were composted and spread on soils, the annual input of these source would amount to 32 up to 163 g (TE)/a, as is shown in the following table.

Beneath composting, **material recycling** belongs to the most important tasks of a modern waste management program. Up to now, recycling of raw material had been more or less regarded as strategy to avoid dioxins. But recent informations show that there should be great scepticism concerning this

Tab. I: Input/output - balance of the MWI BI - HF, TE due to the calculation of the BGA
S: SUMMER - samples from 27.7.1989, W: WINTER - samples from 23.1.1990

		INPUT	OUTPUT		
		PCDD/PCDF (waste)	Output (air, water)	Output + Residues	Output vs. Input
PCDD/PCDF:					
PCDD	S:	98,6	4,8	66,6	0,68
(ng/h)	W:	64,9	7,0	56,2	0,87
PCDF	S:	2,2	15,0	46,6	21,18
(ng/h)	W:	12,3	16,2	54,7	4,45
Sum PCDD/F	S:	101,0	20,0	113,1	1,12
(ng/h)	W:	77,2	23,2	110,9	1,44
Sum PCDD/F	S:	0,25	0,38	1,52	6,08
(ng/h, TE)	W:	0,35	0,39	1,48	4,11
Precursors:					
PCB	S:	9.607	0,4	2,7	0,0003
(ng/h)	W:	4.611	1,4	6,9	0,0015
Chlorobenzenes	S:	2.856	24	133	0,05
(ng/h)	W:	1.120	233	350	0,31
Chlorophenols	S:	55.672	342	430	0,01
(ng/h)	W:	9.399	254	430	0,05

But there is a point, that has nearly never been questioned in the discussion about dioxin emissions of MWI: the question about a possible break-through from the input. At the MWI Bielefeld - Herford, we have analyzed the output and the input, referring to the contamination with dioxins/furans and their precursor substances. The input analyzes were possible, as the input here is homogenized by a large mill.

We found out, that at the MWI Bielefeld - Herford, the output of dioxins, especially OCDD, is smaller than the input. Furans on the other hand show a neglectable input compared to the output. Because of high amounts of OCDD in the input and bigger shares of less chlorinated dioxins and furans in the output, the TE of the output is a little higher than of the input. Taking into account the burden of the residues, one can conclude that municipal waste incineration leads to an increase of toxicity equivalents of nearly factor 5. But further pollution outlet control measurements could reduce this problem by far. If all west german MWIs would realize the new emission standard of 0,1 ng (TE)/m^3 as demanded by ordinance, and would in addition perform thermal treatment for their residues, then MWI would in general result in a reduction of dioxin stock (output vs. input).

Nevertheless, the surprisingly high contents of dioxins in the waste input lead to some questions of greater importance, like e.g.: Which role does the referringly high input of known precursor substances play for dioxin formation? Which role does the dioxin input itself play especially concerning break-through and/or dehalogenation reactions? And the most important question: How do other waste management methods handle the problem of dioxins, furans and their precursor substances in the input?

Tab. 3: Annual soil input of PCDD/PCDF via compost spreading

Assumptions: 30 million t/a wastes, containing 40 - 50 % vegetable waste; weight reduction by composting = 50 %; resulting in 6 - 7,5 million t/a compost

	average content in compost (n = 7) in ug (TE)/t	Spreading of 6 - 7,5 million t/a of this composts on soils result in an input in g/a
PCDD (TE)	5,25 - 19,91	31,5 - 149,33
PCDF (TE)	0,14 - 1,76	0,84 - 13,20
Sum (TE)	5,39 - 21,67	32,34 - 162,53

point of view. Only one example: Copper recycling by cable pyrolysis. Here, the environmental impact of dioxins and furans is frightening. PCDD/PCDF - emissions via "clean" air are reported to be up to thousand-fold higher than those of MWIs (see part IV).

But cable pyrolysis is not the only recycling technique with dioxin problems. Others like aluminium recycling, scrap-iron recycling, waste paper recycling and especially plastic recycling are known or suspected to face the same problem of generation and release of chlorinated and other halogenated dioxins and furans. As many of those plants have no high technical standard, further emission takes place via other routes. Soil contamination with PCDD/PCDF in the near vicinity of these facilities is often up to several hundred-fold higher than the limit for prohibition of agricultural use. Heavy metal contamination has not yet been mentioned, but has to be taken additionally into account. These problems are today discussed mainly without perception of the public. But it can be expected that these themes cannot be held apart from the public in the long run. Can these problems cause the consequence that reasonable measures of waste management have to be given up?

Conclusion

The most important problem of waste management is meanwhile to realize any location for waste management nationwide. This will only become better, if the so-called chemical waste problem is fought at its roots. Reducing the emission limit for MWIs down to 0,1 ng (TE)/m^3 is the first and effective step. This will perhaps result in a shifting of the focus of the public discussion to other waste management techniques. The fight against dioxins and furans may be wone at the "end of the pipe" in case of combustion, in cases of recycling it will never be won. It is urgently necessary to reduce the content of dioxins, furans and precursor substances in wastes, in the INPUT of all these techniques. This can be best achieved by measures in the range, where most precursors are generated: the organochlorine chemistry. This was one of the results of the last dioxin congress in Karlsruhe in january 1990, and this seems to us to be the only measure to drive the discussion to its genuine center! It's a pity that these scientific results and perceptions of the dioxin congress in Karlsruhe have up to now not created further and far-reaching results. Our specific results, too, support the urgent need of a new kind of regarding the dioxin problem!

References

(1) see Part I (values), Part III (formula for Cmax) and: TUEV Hannover: Darstellung und Bewertung der MVA Bielefeld-Herford bezueglich der Verfahrenstechnik und der Emissionen im Bereich Luft und Wasser, Hannover, Oktober 1986

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(3) Hagenmaier H., Universitaet Tuebingen: Dioxingehalte landwirtschaftlich genutzter Boeden, Stand 30.3.1989