PCDD/PCDF BALANCE OF DIFFERENT MUNICIPAL WASTE MANAGEMENT METHODS
II. WASTE DISPOSAL AND DISPOSAL GAS INCINERATION

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Introduction

Though waste incineration is of increasing importance in municipal waste management processes, landfill disposal is still the most commonly practized method. Waste disposal generates liquid and especially gaseous emissions. The latter are mainly unpolar and volatile substances like organic and organohalogene solvents and aerosols and the microbial metabolites of these compounds. At most landfills, gaseous compounds are emitted into the air without control. Only about 40 plants in the FRG have special equipment for gas purification and application at the end of the offtake pipes. At the end of these installations, gas is often treated or used in thermal processes. The authors have analyzed, whether disposal gas or the exhaust gas of thermal treatment of disposal gas contains PCDD/PCDF. Up to now, disposal gas contamination with a wide range of organic compounds has been published, some of them known or suspected PCDD/PCDF - precursors (VC, PCB, di-, tri-, tetrachloromethane, tri- and tetrachloroethene) (1 - 4).

Experimental

Gaseous emissions of two disposal sites were analyzed before and after thermal use. Preparation steps were adsorption on XAD, extraction, chromatographical clean-up, identification and quantification by GC/MS.

The following analyses were conducted:

A 1: disposal gas

A 2: flue gas of a torch (temperature: 890 - 920°C, O^2 < 1 %)

B 1 and B 2: emissions of gas motors fed with disposal gas, both with 12 cylinders, maximum production: 119 kW.

Tab. 1: PCDD and PCDF emitted by several waste disposal gas incinerators, all values (except TE-factor) in ng/m^3

A1 = disposal gas; A2 = flue gas of a disposal gas (A1) torch (7 % oxygen); B1 and B2 = exhaust gas of gas motors fed with disposal gas (3 % O_2); references from other authors: C = exhaust gas of gas motors fed additionally with disposal gas; D = fuel gas of disposal gas incinerators; E = exhaust gas of a disposal gas fed boiling water apparatus. n.m. = not mentioned

ATTENTION: PCDD/PCDF-sums do not contain single isomers listed below

Compounds	TE-factor (BGA)	A1	A2	B1	B2	C* (5)	D** (5)	E (1)
TetraCDD, Sum	0,01	< 0,01	0,685	0,195	0,145	< 0,05	3,0	2,9
(TE)			(0,00685)	(0,00195)	(0,00145)		(0,03)	(0,029)
PentaCDD, Sum	0,01	< 0,01	0,737	0,357	0,30	0,50	1,50	n.m.
(TE)			(0,00737)	(0,00357)	(0,0030)	(0,05)	(0,015)	
HexaCDD, Sum	0,01	< 0,01	1,084	0,351	0,286	0,65	1,20	2,2
(TE)			(0,01084)	(0,00351)	(0,00286)	(0,0065)	(0,012)	(0,022)
HeptaCDD, Sum	0,01	< 0,01	1,428	0,255	0,157	1,10	1,75	n.m.
(TE)			(0,01428)	(0,00255)	(0,00157)	(0,011)	(0,0175)	
OctaCDD	0,001	< 0,01	1,85	0,68	0,45	1,00	4,50	n.m.
(TE)			(0,00185)	(0,00068)	(0,0045)	(0,001)	(0,0045)	
TetraCDF, Sum	0,01	< 0,01	3,23	0,91	0,77	13,70	16,50	14,2
(TE)			(0,0323)	(0,0091)	(0,0077)	(0,137)	(0,165)	(0,142)
PentaCDF, Sum	0,01	< 0,01	1,638	0,723	0,634	5,35	19,80	12,6
(TE)			(0,01638)	(0,00723)	(0,00634)	(0,0535)	(0,198)	(0,126)
HexaCDF, Sum	0,01	< 0,01	0,772	0,601	0,551	3,65	7,55	10,4
(TE)			(0,00772)	(0,00601)	(0,00551)	(0,0365)	(0,0755)	(0,104)
HeptaCDF, Sum	0,001	< 0,01	0,078	0,084	0,036	1,50	3,00	n.m.
(TE)			(0,000078)	(0,000084)	(0,000036)	(0,0015)	(0,003)	
OctaCDF	0,001	< 0,01	0,69	0,1	0,08	< 0,05	2,50	n.m.
(TE)			(0,00069)	(0,0001)	(0,00008)		(0,0025)	
Compounds	TE-factor (BGA)	A1	A2	B1	B2	C* (5)	D** (5)	E (1)
2378-TCDD	1	< 0,01	0,025	0,005	0,005	< 0,05	< 0,05	< 0,02
(TE)			(0,025)	(0,005)	(0,005)			
12378-PentaCDD	0,1	< 0,01	0,023	0,013	0,010	0,15	0,25	n.m.
(TE)			(0,0023)	(0,0013)	(0,001)	(0,015)	(0,025)	
123478-HexaCDD	0,1	< 0,01	0,054	0,022	0,016	0,20	0,25	n.m.
(TE)			(0,0054)	(0,0022)	(0,0016)	(0,02)	(0,025)	
123678-HexaCDD	0,1	< 0,01	0,038	0,013	0,01	0,20	0,30	n.m.
(TE)			(0,0038)	(0,0013)	(0,001)	(0,02)	(0,03)	
123789-HexaCDD	0,1	< 0,01	0,024	0,014	0,008	0,15	0,25	n.m.
(TE)			(0,0026)	(0,0014)	(0,0008)	(0,015)	(0,025)	
1234678-HeptaCDD	0,01	< 0,01	1,172	0,235	0,193	n.m.	n.m.	n.m.
(TE)			(0,01172)	(0,00235)	(0,0193)			
2378-TetraCDF	0,1	< 0,01	0,23	0,04	0,03	< 0,05	< 1,50	1,2
(TE)			(0,023)	(0,004)	(0,003)			(0,12)
12378-PentaCDF	0,1	< 0,01	0,09	0,04	0,035	n.m.	n.m.	n.m.
(TE)			(0,009)	(0,004	(0,0035)			
23478-PentaCDF	0,1	< 0,01	0,072	0,037	0,031	0,75	1,20	n.m.
(TE)			(0,0072)	(0,0037)	(0,0031)	(0,075)	(0,12)	
123478-HexaCDF	0,1	< 0,01	0,094	0,086	0,074	n.m.	n.m.	n.m.
(TE)			(0,0094)	(0,0086)	(0,0074)			
123678-HexaCDF	0,1	< 0,01	0,069	0,067	0,056	0,85	1,45	n.m.
(TE)			(0,0069)	(0,0067)	(0,0056)	(0,085)	(0,145)	
123789-HexaCDF	0,1	< 0,01	0,005	0,004	0,004	n.m.	n.m.	n.m.
(TE)			(0,0005)	(0,0004)	(0,0004)			
234678-HexaCDF	0,1	< 0,01	0,05	0,042	0,045	n.m.	n.m.	n.m.
(TE)			(0,005)	(0,0042)	(0,0045)			
1234678-HeptaCDF	0,01	< 0,01	0,475	0,468	0,453	n.m.	n.m.	n.m.
(TE)			(0,00475)	(0,00468)	(0,00453)			
1234789-HeptaCDF	0,01	< 0,01	0,237	0,298	0,241	n.m.	n.m.	n.m.
(TE)			(0,00237)	(0,00298)	(0,00241)			
Summe PCDD/PCDF			14,85	5,64	4,62	29,75	65,00	43,5
(TE)			(0,217)	(0,088)	(0,075)	(0,682)	(0,893)	(0,543)

* motors with meagre fuel concept

** steam and hot water producer with three parallel steps

Results

While in disposal gas no PCDD/PCDF could be detected, (see A 1), flue gas from different incineration processes are contaminated to an extent with PCDD/PCDF, that lies clearly above the new emission limit of 0,1 ng (TE)/m^3 for municipal waste incinerators. Considerable 1.600 ng/m^3 PCB, potential precursor, were identified in disposal gas (A 1).

The results of the gas analyses on PCDD/PCDF are shown in table 1. In order to compare these emissions with other analyses due to the same source, we have added further measurement published by other authors:

C: exhaust gas of gas motors additionally fed with disposal gas (5)

D: fuel gas of disposal gas incinerators (5)

E: exhaust gas of a disposal gas fed boiling water apparatus (1).

Discussion

It can be suspected that emissions of PCDD/PCDF from solid wastes during disposal is not likely, considering their low volatility. This assumption has to be verified by further investigation, because our single analysis cannot be regarded as solid base for a conclusion of such importance. With regard to direct PCDD/PCDF-release, one may conclude that disposal is the only technique without posing PCDD/PCDF-problems to environment or to man. On the other hand, disposal leads to delive*rance of other pollutants, especially via disposal gas, some of them listed up in table 1.*

Tab. 1: Average contents of organic pollutants in gas emitted from municipal disposals and one toxic waste disposal, in mg/m^3 (3) MAC = maximum allowable air concentration at the working place

* = (technical guide value for) known carcinogens

** = suspected carcinogen

substance	toxic waste disposal	municipal waste disposal	MAC
vinylchloride (VC)*	41	10	5*
1,1-dichloroethene**	7	0	8
cis-1,2-dichloroethene	14	9	790
dichloromethane**	43	7	360
trichloromethan (chloroform)**	6	0	50
tetrachloromethane (TETRA)**	0,02	0	65
trichloroethene**	10	3	270
tetrachloreethene**	7	2	345
dichlorodifluoromethane (R 12)	35	21	5000
trichlorofluoromethane (R 11)	0,9	3	5600
benzene*	9	2	16*
toluene	130	32	380
hydrogen sulphide	2607	48	15
methanethiol	14	5	1
2-butanethiol	35	1	1,5
PCB**, max., two disposals (6)		0,0016 / 0,0032	0,5

For several known or suspected carcinogens, the maximum allowable concentration at the working place is reached, sometimes exceeded. Personnel and residents in the near vicinity are therefore at high health risk. The amounts mentioned are average, not maximum values. Maximum emissions occur in the period during or directly after disposal, especially during the so-called pre-digestion within the *first few months after disposal. During this period, gas take-off by special equipments* (pipes etc.) cannot be realized.

Therefore, disposal gas should be collected and cleaned up. When used in thermal processes, the emissions of these plants have to be looked upon as similiar to MWI effluents. They should therefore not exceed the PCDD/ PCDF-level of 0,1 ng (TE)/m^3.

A short calculation may illustrate the relevance of this claim. The assumptions are:

a) About 70 % of the annually generated 30 million tons of waste are disposed.
b) One ton of this waste generates up to 1500 m^3 disposal gas on average.
c) 90 % of all generated disposal gas is collected (maybe unrealistic high, but surely necessary) and burnt.
d) Incineration of 1 m^3 of disposal gas causes 10 m^3 of exhaust gas.
e) Average PCDD/PCDF-burden of this exhaust gas is 0.1 - 1 ng (TE)/m^3.

This results in a theoretical input from this source of 28,35 to 283,5 g PCDD/PCDF (TE). As every year further 30 million tons of waste arise, this amount can be estimated as annual input. On the other hand, Hagenmaier (7) estimated the annual emission of municipal waste incineration to amount to 400 g PCDD/PCDF (TE)! This comparison leads to the conclusion, that for both sources there is urgent need for effective countermeasures.

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