Levels of polychlorinated dioxins and furans in ambient air, plants and soil as influenced by emission sources and differences in land use

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Introduction

Quantitative information on the levels of polychlorinated dioxins and furans (PCDD/F) in ambient air, plants and soils have been collected between 1989 and 1992 within the scope of numerous investigations to assess the environmental impact of existing waste incinerators and for the site selection procedure for future incinerators in Baden-Württemberg and North Rhine-Westfalia, Germany. These extensive data were aggregated and evaluated according to different land use types and the influence of operating waste incinerators. In most cases, sampling for the different media was conducted at identical sites or in close proximity to each other. The regions studied are moderately or densely populated and urban agglomerations are mixed with agriculture and forests. Traffic density is generally high.

Methods

Ambient air was collected over a period of 72 h on a glassfiber filter and PU-foam. Plant data were gathered from active biomonitoring with the Grass Exposure Method[1] and Curly Kale Exposure Method[2,3] as well as from planted vegetables (curly kale, lettuce) during the growth period, and from meadows during summer and late fall. Soil sampling at the respective sites was differentiated according to land use (agricultural crops or meadows). Labelled standards were added to the freeze-dried plant samples and air-dried soil samples. For analyses, GC/MS systems were used with high-resolution MS for air and plant samples and low-resolution MS for soil samples. Toxicity equivalent values (TE) were calculated according to NATO/CCMS.

Results

At urban sites the levels of PCDD/F in **ambient air** are markedly higher than in rural environments (Fig. 1). One site in a rural environment, which is influenced by a nearby waste incinerator, exhibits levels of PCDD/F similar to rural environments at the higher values (> 50-percentile), but the lower concentrations do not reach the low ranges of rural sites, and are more similar to a level typical for an urban environment. The potential influence of the PCDD/F emissions can only be detected at low concentrations (<50-percentile, < 0.04 pg/m^3 TE_{NATO}).

Plant samples from biomonitors (grass and curly kale) exhibit similar concentrations of PCDD/F in filtered air. At rural and urban sites or at sites influenced by waste incinerators, levels of PCDD/F in curly kale are consistently higher than in exposed grass (Tab. 1). This may be due to the higher sampling efficiency and accumulation of its curly and waxy leaf surface, but also due to the fact that the grass represents pooled samples throughout the growth period (May through September), whereas curly kale is exposed during fall, when atmospheric levels of PCDD/F are generally higher. Due to their exposure at an elevated level (1,5 m above ground level), curly kale and grass used in active biomonitoring exhibit somewhat higher levels of PCDD/F than vegetable plants (curly kale) or meadows. The differentiation between various types of land use or influence by waste incinerators, respectively, is more distinct in biomonitoring plants than in vegetable plants or in herbs and grasses of meadows.

Concentrations of PCDD/F in arable **soils** and under meadows are similar, and both are considerably higher in the vicinity of waste incinerators as compared to rural sites (Tab. 2). Similarly to the pattern of PCDD/F concentrations in the air, these differences are most clearly found with respect to minimum and mean values, whereas maximum values are fairly similar. In the litter layer of forests PCDD/F are significantly accumulated as compared to the humous mineral layer (Ah) and the subsoil (B). These results are confirmed by earlier findings[4].

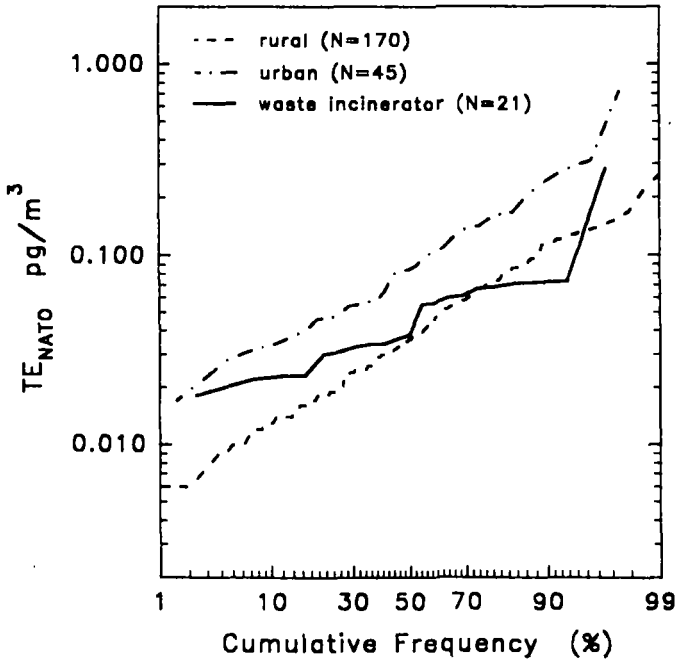

Fig. 1: Levels of PCDD/F in ambient air at rural and urban sites and at a rural site in the vicinity of a waste incinerator. The cumulative frequency distributions of the data, calculated as toxicity equivalents (NATO/CCMS) are presented

Tab. 1: Levels of PCDD/F in biomonitoring plants, vegetables and forage plants at sites differing in land use or influenced by waste incinerators in Baden-Württemberg and North Rhine-Westfalia between 1989 and 1992.

in ng TE/kg dry weight (TE_{NATO} = I-TEF)

type of land use	type of vegetation/ biomonitor	mean	minimum/ maximum	sample size
rural/ suburban	Grass Exposure Method	0,47	0,20 - 1,86	21
	grassland *	0,40	0,04 - 0,75	44
	(Nov./Dec.)	(2,28)	(2,27/2,28)	2
	Curly Kale Exposure Method	1,05	0,44 - 2,20	22
	vegetables:**			
	- curly kale	0,81	0,39 - 2,30	14
	- lettuce	0,58	0,57 - 0,59	4
urban and/or industrial agglomeration	Grass Exposure Method	2,63	1,56 - 3,96	3
	grassland *	0,89	0,70 - 0,99	3
	(Nov./Dec.)	-	-	-
	Curly Kale Exposure Method	3,15	2,26 - 5,91	3
	vegetables:**			
	- curly kale	-	-	-
	- lettuce	-	-	-
influenced by waste incinerator	Grass Exposure Method	2,96	0,21 - 4,54	6
	grassland *	0,87	0,30 - 1,50	8
	(Nov./Dec.)	(9,18)	(7,44/10,91)	2
	Curly Kale Exposure Method	7,04	2,12 - 11,0	3
	vegetables:**			
	- curly kale	4,49	1,6 - 10,0	8
	- lettuce	0,54	0,38/0,70	2
filtered air chamber/ open top chamber ***	Gras Exposure Method	0,36	0,20 - 0,74	4
	Curly Kale Exposure Method	0,32	0,21 - 0,41	6

* sampling during growth period (May through October)

** samples washed and prepared for consumption

*** samples from filtered-air control chambers

Tab. 2: Levels of PCDD/F in soils at sites differing in land use or influenced by waste incinerators in Baden-Württemberg between 1989 and 1992.

in ng TE/kg dry wt. (TE_{NATO} = I-TEF)

region	land use/ vegetation soil layer	rural/ suburban mean (minimum - maximum/ sample size)	influenced by waste incinerator mean (minimum - maximum/ sample size)
Baden-Württemberg	grassland:		
	- 0-10cm	1,35 (0,02 - 7,6 /25)	5,32 (2,1 - 10,2 /5)
	- B-layer	2,8	-
	- C-layer	0,3	-
	field:		
	- 0-30cm	1,08	4,6
	- B-layer	-	0,6
	- C-layer	-	0,01
	garden:		
	- 0-20cm	-	7,0
	forest:		
	- litter (O)	12,28 (1,63 - 85,8 /15)	-
	- mineral soil (Ah)	1,93 (0,27 - 9,6 /15)	-
	- subsoil (B)	0,4 (0,3; 0,5 /2)	-

1 Arndt U, Nobel W, Schweizer, B. *Bioindikatoren.* Stuttgart, Germany: Ulmer Verlag, 1987.
2 Nobel W, Maier-Reiter W, Sommer B, Finkbeiner M. Biomonitoring organischer Luftschadstoffe, insbesondere Dioxine/Furane. *VDI-Berichte* 1992; 901:813-26.
3 Nobel W, Maier-Reiter W, Sommer B, Finkbeiner M, Arndt U. Biological monitoring of organic air pollutants. In: McKenzie, ed. *Ecological Indicators.* Barking/Essex: Elsevier, 1993: 1552-5.
4 Schulz D. Dioxine im Boden. In: Rosenkranz D, Ensele G, Harress HM, eds. *Bodenschutz.* Berlin: Erich Schmidt Verlag, 1992: 1700.