Pathways of Atmospheric PCDD/F to a Native Grassland Culture: The Importance of Particle-bound Deposition

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Abstract

The uptake of atmospheric PCDD/F by native grassland cultures was investigated. In contrast to earlier investigations with ryegrass, it was found that particle bound deposition clearly played an important role in the uptake of congeners with 6 and more chlorine atoms. The importance of this pathway varied from plant species to species and was related to the orientation, exposure and surface characteristics of the leaves. The dominant role of dry gaseous deposition for the accumulation of the lower chlorinated congeners reported in earlier work[1)] was confirmed.

Experimental and Analytical Methods

The experiment was conducted throughout the 1994 growing season on the campus of the University of Bayreuth. The air concentrations of PCDD/F at this site, situated to the south of the city, are low and represent a typical background situation for this area.

The experimental set-up comprised two greenhouses which were supplied with two different kinds of outdoor air: one containing the gaseous and particle bound PCDD/F (greenhouse 1), and one containing only the gaseous PCDD/F in the outdoor air (greenhouse 2). A detailed description of the greenhouses as well as of the air sampling system used to monitor the exposure levels in the greenhouses is given in ref. 1.

Native grassland cultures from a pasture located to the south of Bayreuth were employed in order to simulate a typical agricultural crop. This pasture was classified as *Arrhenatherion elatoris*, a

typical representative of German grassland with a great variety of herbal species. The grass sods were transplanted into containers (78 x 46 x 30 cm; L x W x H). Six containers were placed in each greenhouse, thus providing a vegetation surface of about 2 m^2 per greenhouse. Water was supplied from below through a layer of gravel and a second layer of clay pellets at the bottom of the containers. A fertiliser solution was added to this water reservoir following the first harvest (see below).

The experiment started on April 29, 1994. On June 1 the first harvest was conducted, whereby the cultures in the greenhouses were cut back to about 4 cm. The plant material was wrapped in aluminium foil and stored at - 18 ° C. A second exposure ran from June 15 to August 18. The experiment was concluded with a third harvest on October 11.

The extraction method and clean-up procedure for the grassland samples have been described elsewhere[2]. The HRGC/HRMS analyses were performed on a VG AUTOSPEC ULTIMA at a resolution of 10,000 in the selected ion mode, employing a DB-5-MS capillary column (J&W), 0.25 mm x 0.10 μm.

Results

In contrast to the experiment with ryegrass reported on earlier, the native grassland cultures showed a distinct response to the presence/absence of particle bound PCDD/F in the two greenhouses, in particular for the higher chlorinated homologues which dominate the particle phase[3].

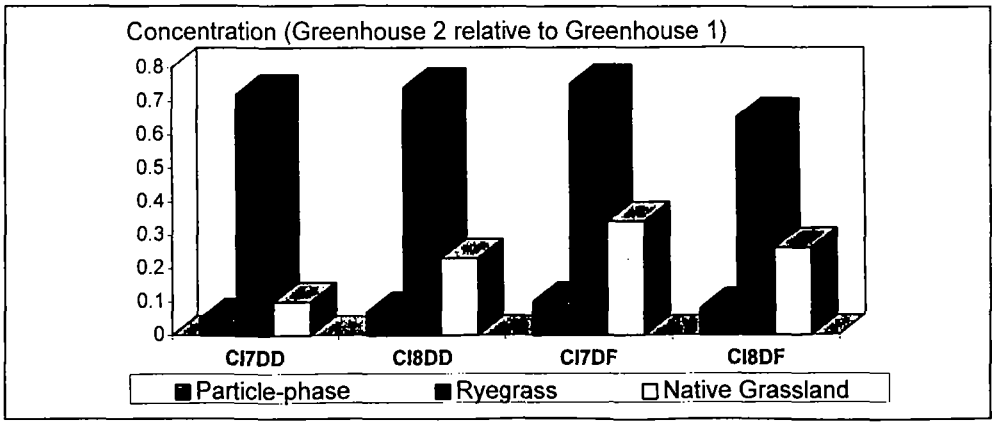

Fig. 1: Response of ryegrass and grassland to the particle-phase gradient

Figure 1 gives the concentrations of the plant samples from greenhouse 2 (gas phase only) normalised to the concentrations of greenhouse 1 (gas and particle phases) for both this experiment and the earlier experiment with ryegrass. The gradient in the particle bound concentrations, which was identical for both experiments, is also shown. It should be noted that the levels of Cl_8DF measured in the samples from greenhouse 2 were close to the limit of quantification.

The native grassland culture clearly responded to a much more greater extend to the particle-phase gradient between the two greenhouses than did the ryegrass. This was attributed to the differences in the plant surfaces and canopy structure. The grassland culture contained many herbal species, some of which had rough leaf surfaces and/or leaves oriented horizontally which are likely to collect particles more effectively than the smooth vertically oriented leaves of ryegrass.

The importance of particle bound deposition and the influence of plant properties were further investigated by analysing different plant species sampled in the pasture where the grassland sods originated from (Fig. 2).

The comparison between the concentrations (pg/g dry weight) found in *Phleum pratense* (which is comparable to ryegrass (*Lolium multiflorum*)) and *Heracleum sphondylium* demonstrates that, while the concentrations of the lower chlorinated congeners are similar, the rough hairy surface and nearly horizontal orientation of the *Heracleum* leaves leads to higher levels of the particle bound Cl_7- and Cl_8DD.

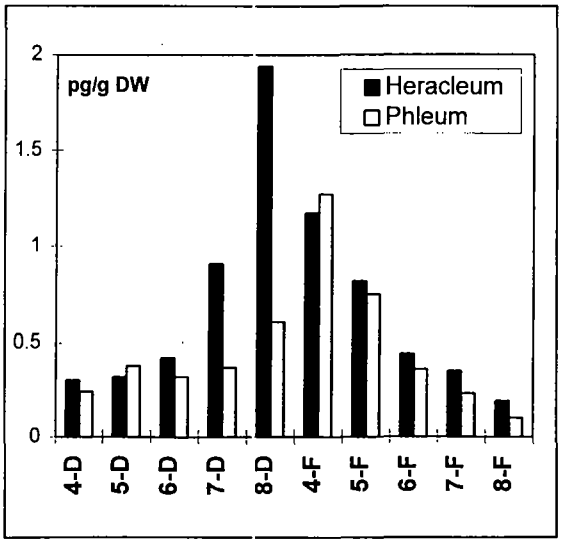

Fig. 2: Comparison between *Phleum pratense* and *Heracleum sphondylium*

These findings are also reflected in the levels found in the rich pasture and a second xeric grassland community. The atmospheric concentrations were identical at both sites, and this is reflected in similar levels of the lower chlorinated (gaseous) congeners. However, the uptake of particle bound Cl_8DD and Cl_7DD by the rich pasture was almost a factor of 2 higher than by the xeric grassland community.

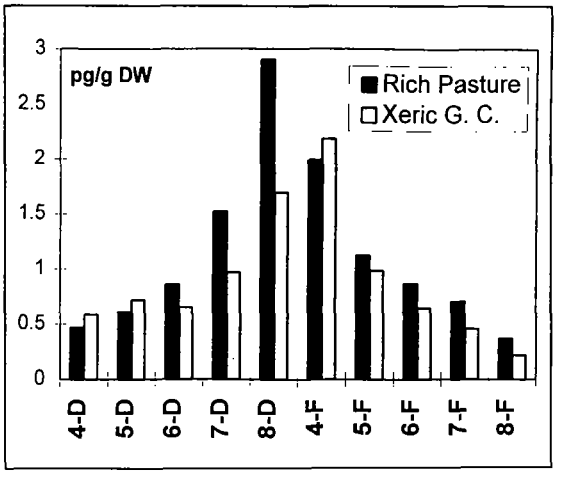

Fig. 3: Comparison between a rich pasture and a xeric grassland community

In this case the relatively high leaf area index[4)] of the rich pasture compared to the xeric grassland community and/or the different mixture of species makes the rich pasture a more efficient "particle scavenger" on a dry plant weight basis.

Further investigations are underway with the aim of identifying the influence of wet deposition on the uptake of particle-bound PCDD/F.

Acknowledgements

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References

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