Transfer of PCDD/PCDF from Contaminated Soils into Carrots, Lettuce and Peas

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Introduction

The consumption of contaminated food of animal origin is considered to account for over 90% of the human body burden of PCDD/PCDF[1]. In order to prevent the production of contaminated crops, the Ministry of Environment of Baden-Württemberg (Germany) has released thresholds allowing unrestricted agricultural practice only on soils with less than 5 ng I-TEq/kg, and requiring special techniques for soils containing 5-40 ng I-TEq/kg. On soils with concentrations higher than 40 ng I-TEq/kg only crops with proven minimal PCDD/PCDF uptake (e.g. fruit trees, cereals) are allowed to be cultivated. However it has to be kept in mind that not only the soil is a source of contamination but also atmospheric depositions might play an important role in the PCDD/PCDF contamination of plant shoots[2-5].

Objectives

In order to evaluate different pathways contributing to plant contamination, field trials were set up on soils with two different levels of contamination. Carrots, lettuce and peas were cultivated, yielding various consumable fractions. The following aspects were examined:

1. the extend of PCDD/PCDF contamination of carrots, lettuce and peas;
2. differences in PCDD/PCDF levels of internal (inner parts of carrot roots, inner leaves of lettuce, seed of peas) and external (carrot peel, outer leaves of lettuce, pods of peas) plant parts;

3. differences in contamination pathways of PCDD/PCDF into aerial plant parts and plant parts grown in the soil;
4. the possibility to reduce PCDD/PCDF contamination of aerial plant parts by covering the contaminated soil with a thin layer of uncontaminated soil.

Experimental

The trial was set up in the vicinity of a former electric wire scrap incinerator for metal reclamation near Crailsheim, Germany. The two selected plots had PCDD/PCDF concentrations of 5 (control plot CP) and 56 (trial plot TP) ng I-TEq/kg soil, respectively. According to the recommendations of the Ministry for Environment of Baden-Württemberg, the concentration of the trial plot represents the threshold of acceptable PCDD/PCDF concentrations in soils for agricultural use. As a special treatment one of the higher contaminated plots was covered with a thin layer (about 5 cm) of uncontaminated soil (TP+).
All vegetables were washed after the harvest, and then separated into different fractions:
carrots: peel, cortex and stele
lettuce: outer leaves and inner leaves (completely enclosed by the outer leaves)
peas: seeds and pods
PCDD/PCDF concentrations of soil and plant materials were determined at ERGO-Forschungsgesellschaft mbH, Hamburg, Germany.

Results and Discussion

Soil analyses showed that the PCDD/PCDF concentration of the higher contaminated trial plot (TP) was approximately ten times greater (both in terms of I-TEq and total PCDD/PCDF) than the control plot (CP) (Table).

Table: Soil contamination level in I-TEq and total PCDD/PCDF of the control and the trial plot (0-10 cm depth) on a dry matter (DM) basis

	Control plot (CP)	Trial plot (TP)
I-TEq (ng/kg DM)	5	56
total PCDD/PCDF (ng/kg DM)	363	3223

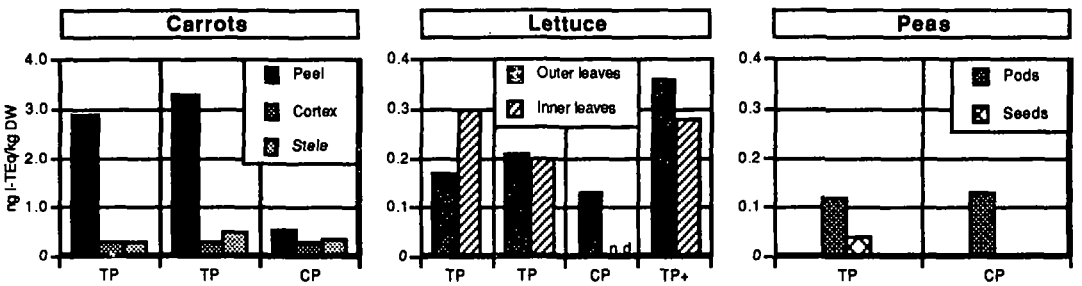

Figure: Contamination (in I-TEq) in different fractions of carrots, lettuce and peas grown on a contaminated plot (TP), on a contaminated plot with an uncontaminated topsoil cover (TP+), and on a control plot (CP)

The PCDD/PCDF homologue distribution pattern in the soil of the trial plot is characterized by an increase in concentration from the lower to the higher chlorinated PCDD and PCDF (data not shown).

Among the vegetable samples, the peel of the carrots on the trial plot had the highest contamination level with 2.9-3.3 ng I-TEq/kg dry weight (DW), compared with 0.55 ng I-TEq/kg DW in carrot peel from the control plot (Figure). These results indicate that the contamination source for the peel of carrots is the soil. In carrot samples from the more highly contaminated soil, the inner fractions (cortex and stele) had much lower levels than the peel. No significant difference existed between the levels of PCDD/PCDF contamination in the inner fractions of carrots grown on the more highly contaminated plot and the control plot.

The contamination of lettuce was in the range of 0.1-0.4 ng I-TEq/kg DW (Figure). No significant differences in contamination of lettuce were found between trial plot and control plot, or between the plot with an uncontaminated top layer (TP+) and the trial plot. The homologue pattern in the lettuce plant samples is dominated by higher chlorinated dioxins and lower chlorinated furans, a pattern which is often found in ambient air samples[6]. However, no significant differences in PCDD/PCDF contamination pattern and level between inner and outer leaves of lettuce were observed. Given that the uptake from the air is the main contamination source, a main pathway of PCDD/PCDF to inner leaves is likely to be via the outer leaves, namely by diffusion or translocation in the phloem[2]. Covering contaminated soil with a thin layer of uncontaminated soil did not lead to a significant reduction of the PCDD/PCDF level in lettuce and therefore seems to be ineffective as a means to reduce contamination of aerial plant parts.

Peas from the contaminated plot showed PCDD/PCDF concentrations of 0.04 ng I-TEq/kg DM and 0.12 ng I-TEq/kg DW in seeds and pods, respectively. Even lower concentrations (close to the detection limit) were found in samples from the control

plot. Of all plant samples of this study, peas showed the lowest PCDD/PCDF concentrations. The homologue pattern in peas was dominated by higher chlorinated dioxins and lower chlorinated furans, a finding similar to the pattern in lettuce. Therefore, the accumulation of airborne PCDD/PCDF is suggested as the major pathway for peas.

Conclusions

1. The PCDD/PCDF contamination of carrots was related to the contamination of the soil.
2. Most of the PCDD/PCDF burden found in carrots grown on the higher contaminated plot was associated with the peel.
3. Contamination of lettuce and peas with PCDD/PCDF was much less than in carrots, and was not related to soil levels.
4. The contamination of lettuce and peas appears to be due to uptake of PCDD/PCDF from the air.

References

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