UPTAKE PATHWAYS OF OCTACHLORODIBENZO-P-DIOXIN FROM SOIL BY CARROTS

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OBJECTIVES

The transfer pathways by which food plants are contaminated with polychlorinated dibenzo-p-dioxins (PCDDs) are poorly understood. Field experiments and field observations reported so far gave indications of a clear soil-plant contamination relationship only for root crops such as carrots[1-3]. PCDD concentrations in the shoots of potatoes[1], in hay[1], lettuce[1,3], endives, spinach and kale[2] did not exhibit any quantitative relationships to those in the soils where they had been grown.
In order to contribute to a potential prediction of PCDD residues, also in aerial plant parts, from soil concentration, the soil-borne portions of residues in shoots have to be quantified separately from those portions that are not related to the soil where the plants grow. Soil-borne residues in the plant tops are those resulting from translocation from the roots as well as those taken up by leaves from the air after vaporization from the contaminated soil. Experiments must be carried out in contaminated soil excluding background air contamination.
In this paper the uptake pathways of ^{14}C-labelled octachlorodibenzo-p-dioxin (OCDD) by carrots from soil in a closed plant-soil system[4] via roots and leaves in non-contaminated air is presented. The concentration used in this study was about 6.4 ng/g dry soil. This concentration corresponds to that determined in highly contaminated agricultural soils[1].

MATERIAL AND METHODS

The soil used for the studies was an Ap-horizon of an agricultural soil. The analysis of the soil (after passing through a 2 mm sieve) showed 16% clay, 63% silt and 21% sand; pH: 6.0; organic matter content: 2.65%.
The ^{14}C-labelled OCDD was synthesized by Chemsyn Science Laboratories (USA); specific *activity: 120 mCi/m mole; radiochemical purity:* 99.9994%, *achieved by thin layer* chromatography.

The test system is shown in Fig. 1[4]. The tests were performed in a 10 l desiccator connected to a series of absorption tubes to collect volatile organic substances as well as $^{14}CO_2$ in the air of the system. The desiccators contained on one hand a soil treated with ^{14}C-labelled chemicals where plants were grown and, on the other hand, a smaller second glass dish with untreated soil and a special equipment avoiding the contamination of the untreated soil with gaseous radioactive air components resulting from the volatilization of ^{14}C-xenobiotics from the "treated" soil. Thus, plants grown in this second dish can take up the ^{14}C-labelled chemicals only by the leaves. In contrast to these plants, plants grown in the soil "treated" with ^{14}C-labelled chemicals can take up the chemical by the roots and by the leaves.
The air that was drawn through the apparatus was precleaned in a charcoal tube before entering the plant chamber. Carrots precultivated for 34 days were planted into the test system and grown for 14 days. Then, the plants were divided into cotyledons, stem parts with soil contact, stem parts without soil contact, leaves, and roots. The radioactivity in the plant material and in the soil was determined by combustion in an automatic sample oxidizer (Packard, Tri-Carb 306); $^{14}CO_2$ trapped was measured in a liquid scintillation counter (Berthold 8000, FRG).
The liquids in the trapping system were analyzed by liquid scintillation counting, as described previously[4]. The cover and glass walls of the desiccator were carefully cleaned with glass wool and acetone. The glass wool was washed with acetone. The ^{14}C in the acetone was determined by liquid scintillation counting also. The tests were done as duplicates.

RESULTS

The mass balance of OCDD in the two experiments was 98 or 101%, respectively. ^{14}C in the treated plants was about 0.01% of the applied ^{14}C, in plants grown in untreated soil 0.003%. Traces of volatilized radioactivity were detected on the glass walls of the chamber, whereas no ^{14}C was found in the absorption tubes for volatile organics in the air and for $^{14}CO_2$.
The residue concentrations of ^{14}C-OCDD in the different parts of the carrots are shown in Table 1. The data show that soil-borne OCDD is taken up both in roots and in shoots of carrots. The OCDD in the roots originates only from uptake from soil by the roots, and that in the leaves only from foliar uptake from the air, where it has come by volatilization from the soil.

CONCLUSION

It may be concluded that OCDD is not translocated in carrot plants from the roots to the shoots. Also, no transport of OCDD from the shoots to the roots could be observed. However, OCDD volatilizing from the soil can contaminate the plant leaves to a measurable degree, if soil contamination is high.

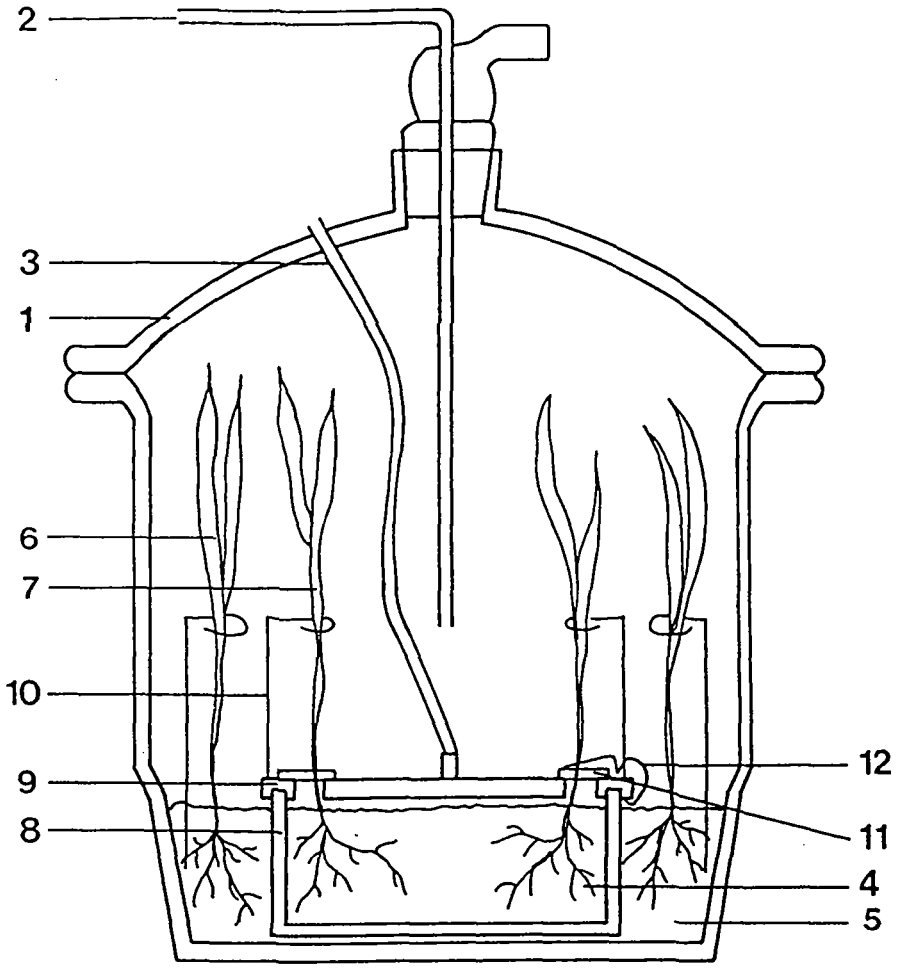

Fig.1. Closed System for Testing the Uptake Pathways of Chemicals in Plants

1 Desiccator
2 Desiccator ventilation
3 Teflon tube
4 Control soil
5 Test soil
6 Test plants
7 Control plants
8 Control dish
9 Teflon plate
10 Steel wire
11 Small teflon pieces
12 Metal cramps

Table 1: Concentration of OCDD in Plant Material

		Concentration ng/kg (FM)	
		Test I	Test II
"Treated plants"	Cotyledons	67.0	77.5
	Stem, lower part (with soil contact)	201.0	254.2
	Stem, upper part (without soil contact)	-	-
	Leaves	59.1	49.1
	Roots	259.1	536.4
"Untreated plants"	Cotyledons	65.0	80.2
	Stem	-	-
	Leaves	59.8	46.7
	Roots	-	-

FM: Fresh plant material

REFERENCES

1. Hülster A, Marschner H. Die Bedeutung des Transferfaktors Boden/Pflanze für Dioxine. Lecture given on the 3. Expertengespräch "Gefährdungspotentiale im Bodenschutz", Beurteilung organischer Bodenkontaminationen am Beispiel der Stoffgruppen Dioxine und Phthalate, München-Neuherberg, 11. - 13. 3. 1992
2. Ende M. PSDD/F-Untersuchungen von ausgewählten landwirtschaftlichen und gärtnerischen Produkten aus dem Umfeld einer Altlast sowie anderer, unterschiedlicher Regionen. Lecture given on the BMFT/GSF Workshop "Ursachen und quantitative Beziehungen bezüglich der Belastung von Futter- und Nahrungspflanzen sowie bodengehaltener Nutztiere mit Dioxinen", München-Neuherberg, FRG, 22. - 23. 4. 1992
3. Krause GHM, Prinz B, Radermacher L. PCDD-Transfer über die Pfade Boden/Pflanze und Luft/Pflanze. Lecture given on the BMFT/GSF Workshop "Ursachen und quantitative Beziehungen bezüglich der Belastung von Futter- und Nahrungspflanzen sowie bodengehaltener Nutztiere mit Dioxinen", München-Neuherberg, FRG, 22. - 23. 4. 1992
4. Schroll R, Scheunert I. A laboratory system to determine separately the uptake of organic chemicals from soil by plant roots and by leaves after vaporization. Chemosphere 1992; 24: 97-108.