Uptake and Translocation of Hexachlorobenzene - Oilpumpkin and Sunflower

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Introduction

In contrast to well known environmental chemicals, Hexachlorobenzene (HCB) does not have a distinct pattern of use which would make it more easy to estimate the amount of production entering the environment. Whereas HCB pollution arose from its use as a seed protecting fungicide and a wood preservative until the late 1970's, today HCB contamination mainly arises from different chemical production processes (chemical intermediate, polymer additive) and incineration processes. A quantitative correlation was found between the formation of polychlorinated dioxins and dibenzofurans and the formation of HCB at incineration processes of PVC respectively polychlorinated benzenes containing wastes[1]. Although several sources of HCB emissions existi t was mentioned that the problem caused by this chemical does not generally arise from a large emission volume but rather from its high persistence and accumulation potental along the food chain[2].

The assessment of the uptake of organic xenobiotic substances by plants and the recognition of the main pathways of contamination are of great importance for their toxicological and ecotoxicological evaluation.

The uptake of HCB by various plant species has been investigated. The results show that no translocation of HCB exists within the plants[3]. HCB and other volatile, lipophilic pollutants are taken up by foliage as gases[3,4].

Since surprisingly high amounts of HCB were found in the seeds of oilpumpkins grown in Austria (Styria) it was of great concern to investigate the possible contamination pathways of this plant[5]. As a comparison the same experiments were carried out with sunflowers as an oil seed with different morphological characteristics.

Material and Methods

Open air pot experiments were designed with pumpkin plants (*Cucurbita pepo* var. *citrullinia* f. *styriaca* Greb.) and sunflowers (*Helianthus annuus*) growing on a Pseudo-Chernozem (5,5% OC; pH 7,5). HCB was added to the soil in concentrations of 1, 2, 3, 5, 20, 30 and 40 ppm.

In order to investigate transport and accumulation of HCB in the plants more particularly pumpkins and sunflowers were exposed to radiolabelled nutrient solution for different times. The concentration of ^{14}C-HCB in the solution was 5 µg per l which is equivalent to 225 nCi/l. Plants were grown in 5l glasses which were covered with glass plates in order to minimize evaporation of the chemical into the air. The amount of radioactivity in different parts of the plants was determined by scintillation counting and the HCB concentrations were calculated. It can be assumed that the measured radioactivity is equivalent to unchanged HCB as the chemical does not undergo considerable metabolism in the plant or in the medium[6,7].

Autoradiographic pictures of cross-sections of stems and young pumpkin fruits were made. (Exposure time: 32 days).

In addition 4 pumpkin plants were exposed to the radiolabelled nutrient solution for 16 days and then transplanted to uncontaminated soils where they ripened.

Results and Discussion

Soil contamination even at the lowest level (1 ppm HCB in the soil) causes a significant increase of HCB concentration in the oil pumpkin seeds, up to 3,4 mg/kg oil. Higher quantities of HCB in the soil (>2 ppm) do not have a further effect on concentrations in the seeds (Fig. 1). Comparative experiments with sunflowers show that the contamination levels of the soils do not cause any differences in the contamiation of the seeds with HCB. The HCB concentration throughout was 2-4 ppb HCB in the oil. As the plants were grown in pots and the pumpkin fruits and shoots were lying on uncontaminated ground, it can be assumed that HCB was taken up by the root system and transported to the fruits. HCB evaporates from soil to a certain extent and leads to contamination of the surrounding air. The uptake of gaseous HCB by foliage is the reason for the contamination of the control plants.

Table 1 shows the results of the experiment with radiolabelled nutrient solution. The pollutant was found to be taken up easily via the liquid phase by pumpkins and translocated quickly to all parts of the plants. Intensive accumulation was found in the blossoms and in young fruits. Contamination of control plants is due to evaporated HCB.

In comparison HCB also showed a certain mobility within the sunflowers but the amounts of HCB taken up were considerably lower (Table 1). In contrast to the pumpkin plants, no intensive accumulation was found in the reproductive organs.

The pumpkin plants transferred from nutrient solution to uncontaminated soil after 16 days show the efficient HCB translocation within the plant (Table 2). The amount of HCB found in the ripe seeds was 21-31 ng/g oil. (Control plants: 0,03 ng HCB/g oil).

By means of autoradiographic pictures of cross sections of stems and young fruits/ovaries HCB could be localized in the vascular bundles as well as in the ovules of oil pumpkin plants (Fig. 2).

Conclusions

HCB concentrations found in the seeds of pumpkin plants can be attributed to an uptake of the chemical via the root system and a subsequent translocation to the shoots and reproductive organs. Such mechanisms were not found in sunflowers. Morphological and growth characteristics of the oil pumpkin enable intensive accumulation of HCB. Species of the Cucurbitaceae seem to have a unique ability to translocate and accumulate lipophilic organic substances in the plant[8]. Under field conditions, the uptake of vaporized HCB from contaminated soil by foliage and fruits of oil pumpkins is assumed to be the main pathway of contamination.

References

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Fig. 1: HCB-concentrations in the oil of pumpkin seeds after soil treatment

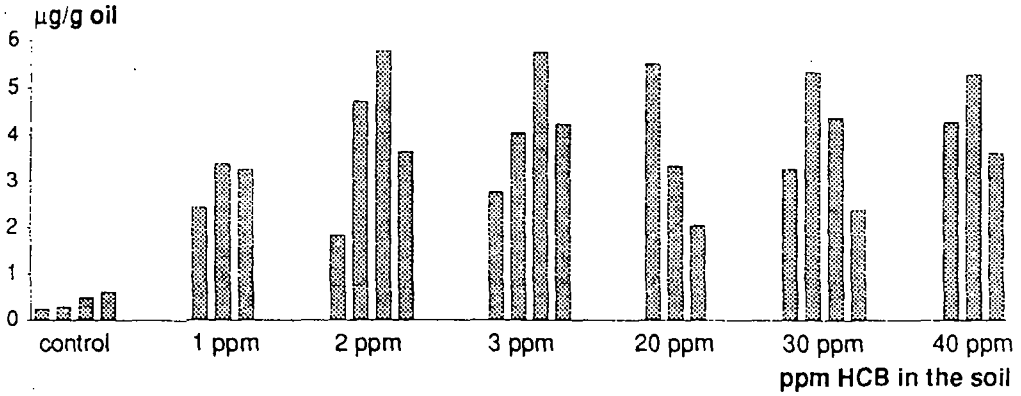

Table 1: 14C-HCB concentrations in oil-pumpkins and sunflowers after 45 d in radiolabelled nutrient solution

No.	section of plant	ng 14C-HCB/kg FW
SF 1 (control)	leaves total	569,80
	stem total	17,60
	young inflorescence	130,00
SF 2	leaves 1 - 14	<814,50
	leaves 15 - 23	224,20
	stem (lower part)	1047,50
	stem (upper part)	9,45
	shoot top	-
SF 3	leaves 9 - 14	496,80
	leaves 15 - 26	260,50
	stem (lower part)	519,70
	stem (upper part)	11,66
	shoot top	264,28
P 1 (control)	leaves 1 - 10	49,80
	leaves 11 - 16	49,80
	stem (lower part)	15,40
	stem (upper part)	16,00
P 2	leaves total	2932,80
	stem total	21926,00
	blossoms	20286,00
P 3	leaves total	2213,50
	stem total	7801,00
	blossoms	10975,00

Fig. 2: Autoradiography Cross section of stem (a) and young fruit/ovaries (b) of oil pumpkin

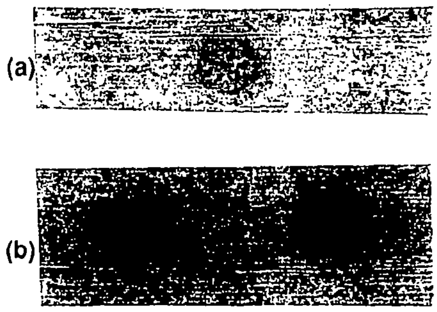

Table 2: 14C-HCB concentration in the oil of pumpkin seeds

No.	treatment	ng 14C-HCB/g oil
1	control	0,026 ± 0,013
2		0,036 ± 0,063
3	16 d in radiolabelled nutrient solution	31,45 ± 0,32
4		22,75 ± 0,17
5		21,92 ± 0,18
6		21,85 ± 0,10