Uptake of PCDDs and PCDFs by radish plant

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Introduction

Dietary intake of polychlorinated dibenzo-*p*-dioxins(PCDDs) and polychlorinated dibenzofurans (PCDFs) through food is considered to account for over 90% of the total PCDDs/DFs human body burden.[1-3] The intake by consumption of vegetables is small. However, plants are important as they come first in the food chain. The main pathway of PCDDs and PCDFs into plants is atmospheric deposition. We also elucidated that the PCDDs/DFs contamination of the leaf of the potato was derived from the air.[4] Plants have been proposed to serve as biomonitors of atmospheric pollution.[5] We examined the concentrations of PCDDs /DFs in different parts of a radish plant that had been grown in acrylic chamber, to evaluate the uptake amount of the radish plant from the environmental air.

Materials and methods

The radish plants(*Raphanus sativus* L.cv.Comet) were cultivated with culture soil in the charcoal-filtered treatment (CF) and in the non-filtered treatment (NF) in acrylic chambers(47×47×115 cm). The CF was aerated through a dust filter with activated charcoal filter at the air inlet. The NF was aerated through a dust filter without the activated charcoal filter at the air inlet. Two boxes were established outdoors(Oct.9~Nov.10, 1993). A fan was used for pneumatic supply to the inside of boxes. The radishes cultured in the boxes were collected and washed with water and then separated into different parts. Each radish was separated into leaf, main root, lateral root and peel of the main root. Each part of the radish plant was extracted with acetone and the soil samples were extracted with methanol/benzene by using a Soxhlet extractor for 24 hrs. The extracts were fortified with ten kinds of ^{13}C-label PCDDs/DFs as internal quantification standards. The extracts were purified on a $AgNO_3$-Silica gel and charcoal columns. PCDDs/DFs were analyzed by HRGC/HRMS in the EI mode with a Finnigan MAT 95 mass spectrometer (Finnigan MAT, Germany) directly interfaced to a Varian Model 3400 gas chromatograph. HpCDD/CDF and OCDD/CDF were measured with 50% methyl phenylsilicon, OV-17 (0.25mm × 60m; film thickness, 0.25μm) and for the analysis of PCDDs/DFs, a SP-2331 capillary column (0.32mm × 60m; film thickness, 0.2μm) was used. The mass resolution (5 % valley) was about 7000.

Results and discussion

The number of leaves and total wet weight of the radish plants cultivated in the NF did not significantly differ from those of the plants cultivated in the CF in this experiment. This experimental system did not affect the growth of the radish plants. Table 1 shows the concentrations of PCDDs/DFs in each part of the radish plant cultured in the chambers, the seed and soil specimen. A significant difference existed between the PCDDs/DFs concentrations of the leaves cultivated in the CF and those in the NF. The total PCDDs and PCDFs concentrations were 3 and 5 times lower in the CF than in those cultured in the NF. Nevertheless, the PCDDs/DFs concentrations of other parts of the radish plants cultured in the CF and NF were similar. The difference in PCDDs/DFs concentration in the radish plant with the two treatments was recognized in only the leaf and the PCDDs/DFs absorbed by the leaves did not shift to the main root. A pneumatic influence was recognized as previously reported.[4)] The differences of the PCDDs /DFs concentrations of the leaves cultured in the CF and NF represent the absorption from atmospheric gaseous air around the chamber. These differences were almost equal to the findings reported by Kurokawa *et al* that the concentrations of PCDFs were about 2 times higher than that of PCDDs in the environmental air.[6)] The concentrations of the main root were much lower than that of the peel as was reported by Müller *et al.*[2)] Moreover, the PCDDs/DFs concentrations of the main roots were markedly lower than those of the lateral root. These results suggested that PCDDs/DFs were hardly transferred from the lateral root to the main root as we previously reported for the potatoes.[4)] The congener distribution of PCDDs /DFs in the leaf was different from that of the soil specimen. The major congeners in the leaves wereTCDDs and TCDFs. On the other hand, the major congener in the soil specimen was OCDD. The distribution of OCDD in each part of the radish decreased more clearly than that in the soil specimen. The congener distributions of PCDDs /DFs in the leaves were similar to that in the environmental air. The congener distribution of the differences which represents the absorption from the environmental air around the chamber resembled that of the environmental air reported by Kurokawa et al.[6)] (Fig.)

Table 2 shows the amounts of PCDDs/DFs in each part of the radish plants cultured in the chambers and of the seed. The PCDDs/DFs amounts of the radish leaves cultivated in the NF was obviously much higher than that in the CF. The total amounts of the PCDDs/DFs of the leaf cultivated in the NF and that in the CF were 466 pg/radish, 123 pg/radish, respectively. With the growth of the radish, the absorption had increased 250 times and 70 times compared with the seed. The amount of the increase dependence on the environmental gaseous air was the difference in the amount between the radish cultivated in the NF and that in the CF, 340 pg/radish. This amount is about 70% of the total amount of absorption by a radish, and about 200 times of the amount in the seed.

Conclusions

1. The total PCDDs /DFs concentrations of the radish leaf cultured in the charcoal-filtered treatment were obviously low than those in the non-filtered treatment in the acrylic chambers.
2. PCDDs/DFs in the leaves and the lateral roots did not shift to the main roots.
3. The amount of the increase dependence on the environmental air was 340 pg/radish, about 200 times of that in the seed.

References

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Table 1 Concentrations of PCDDs/PCDFs in radish plant as pg/g dry basis

	Non-filtered			Charcoal-filtered					
Congener	Leaf	Main root	Lateral root	Leaf	Main root	Lateral root	Peel	Seed	Soil
TCDDs	154.6	5.8	91.4	29.1	3.2	112.8	41.0	56.7	8.1
PnCDDs	60.5	1.4	18.0	10.4	0.9	18.4	17.2	5.7	3.2
HxCDDs	25.9	1.5	8.7	7.6	0.6	8.1	14.0	0.9	6.9
HpCDDs	14.8	0.3	14.0	9.2	0.4	15.4	7.9	3.7	26.3
OCDD	44.3	2.4	217.5	36.5	2.5	193.2	37.5	32.1	2833.9
Total PCDDs	300.1	11.4	349.6	92.8	7.6	348.0	117.6	99.2	2878.4
TCDFs	303.4	3.1	44.1	40.4	2.5	54.9	35.7	17.5	4.1
PnCDFs	119.7	2.0	29.7	16.7	1.3	24.8	14.3	9.6	2.0
HxCDFs	33.1	1.9	23.9	6.4	1.0	34.8	8.1	9.0	2.2
HpCDFs	7.1	0.0	4.5	1.6	0.1	5.6	3.1	1.1	2.2
OCDF	3.3	0.0	0.0	2.4	0.0	0.0	4.6	4.1	1.9
Total PCDFs	466.6	7.0	102.2	67.4	4.9	120.1	65.9	41.2	12.4
Total PCDDs/DFs	766.7	18.5	451.8	160.2	12.4	468.1	183.5	140.4	2890.8
Total PCDDs TEQ	1.8	0.2	1.5	0.5	0.1	1.3	1.8	0.2	3.6
Total PCDFs TEQ	3.8	0.3	4.7	1.0	0.2	5.4	1.4	1.5	0.2
Total PCDDs/DFs TEQ	5.5	0.5	6.2	1.5	0.3	6.6	3.1	1.6	3.8

Table 2 Amounts of PCDDs/PCDFs in radish plant as pg/radish

	Non-filtered				Charcoal-filtered				
Congener	Leaf	Main root	Lateral root	Total	Leaf	Main root	Lateral root	Total	Seed
TCDDs	84.7	7.42	4.53	96.7	15.8	4.26	4.70	24.7	0.72
PnCDDs	33.2	1.80	0.89	35.9	5.6	1.16	0.77	7.6	0.07
HxCDDs	14.2	1.91	0.43	16.5	4.1	0.79	0.34	5.2	0.01
HpCDDs	8.1	0.41	0.70	9.2	5.0	0.52	0.64	6.1	0.05
OCDD	24.3	3.11	10.79	38.2	19.8	3.40	8.04	31.2	0.41
Total PCDDs	164.5	14.66	17.34	196.5	50.3	10.12	14.49	74.9	1.26
TCDFs	166.3	3.99	2.19	172.4	21.9	3.33	2.29	27.5	0.22
PnCDFs	65.6	2.52	1.47	69.6	9.0	1.68	1.03	11.7	0.12
HxCDFs	18.2	2.42	1.19	21.8	3.5	1.29	1.45	6.2	0.11
HpCDFs	3.9	0.06	0.22	4.2	0.8	0.18	0.23	1.3	0.01
OCDF	1.8	0.00	0.00	1.8	1.3	0.00	0.00	1.3	0.05
Total PCDFs	255.7	8.98	5.07	269.8	36.5	6.48	5.00	48.0	0.52
Total PCDDs/DFs	420.2	23.6	22.4	466.2	86.7	16.6	19.5	122.8	1.8
Total PCDDs TEQ	1.0	0.3	0.1	1.3	0.3	0.1	0.1	0.4	0.00
Total PCDFs TEQ	2.1	0.3	0.2	2.7	0.5	0.3	0.2	1.0	0.02
Total PCDDs/DFs TEQ	3.0	0.6	0.3	3.9	0.8	0.4	0.3	1.5	0.02

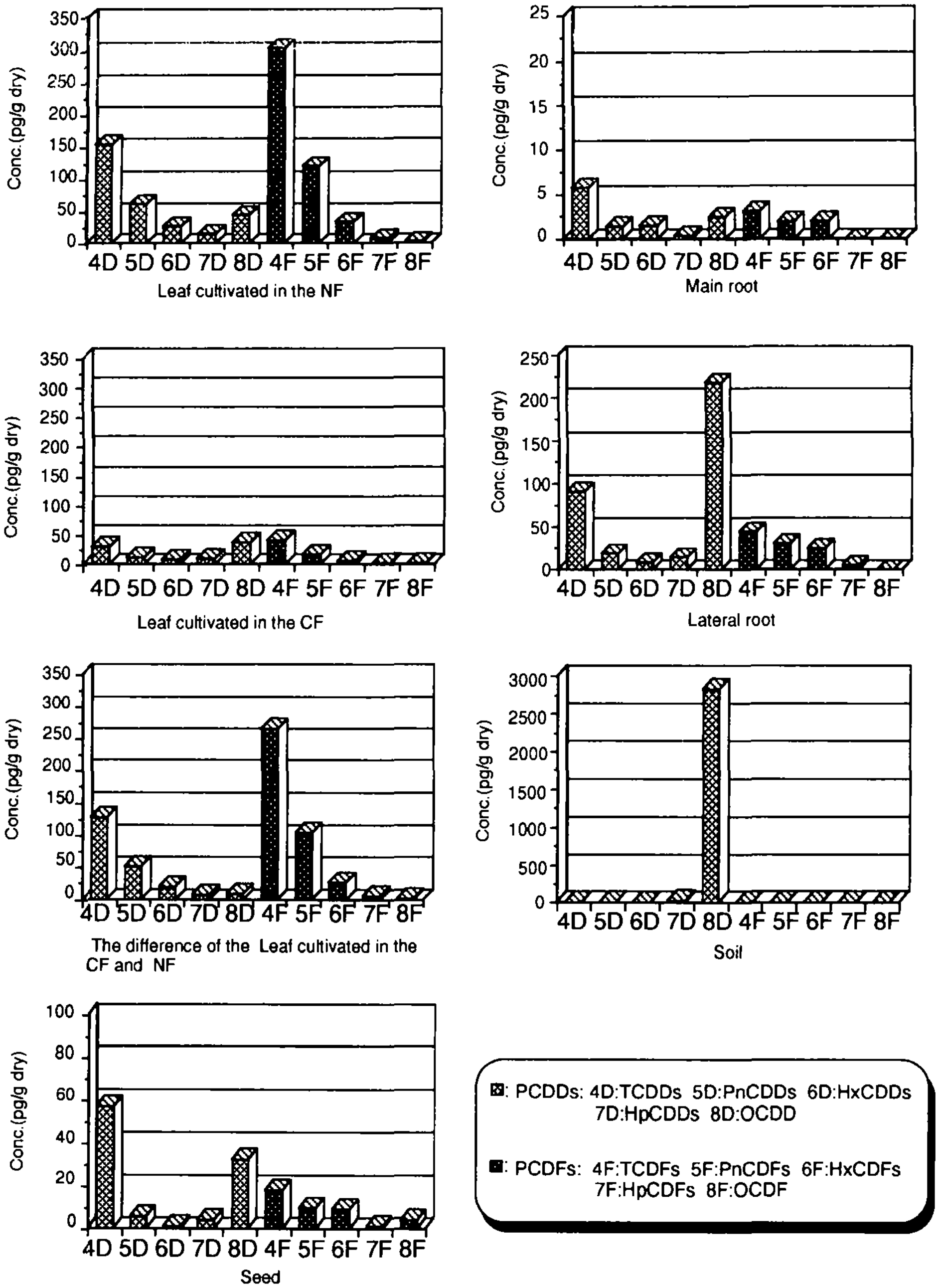

Fig. Congener distributions of the radish plant