# STUDIES OF THE TRANSFER OF PCDD/Fs FROM SOIL INTO JAPONICA RICE

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## Introduction

Polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in the environment are one of the major concerns for the public health. The numerous amount of scientific and public attention has been given to PCDD/Fs during the past decade, since PCDD/Fs display a strong tendency to accumulate in terrestrial food chains.[1,2,3] However, not much has been achieved in the knowledge of the influences of PCDD/Fs in agricultural crops. The intake by consumption of agricultural crops has been considered negligible. This is one of the main reasons for less studies of the PCDD/Fs behavior into crops compared to other area of studies for PCDD/Fs. In fact, the systematical investigation of the transfer of PCDD/Fs from soil into rice has been neglected, despite the fact that rice is the most important crop for many Asian. The studies of PCDD/Fs levels in rice provide thus important information for the assessment of public health risks.

## Materials and Methods

Koshihikari (paddy rice) and Fukuhatamochi (upland rice) are the main variety of rice in Japan. They were cultured in Wagner's pots filled with contaminated soil, 1/2000a at phytotron glasshouse, respectively. Prior to sowing, 0.3g each of N, $P_2O_5$ and $K_2O$ was applied to a pot and mixed with the soil. The cultivation experiments were conducted under natural sunlight in rooms of the phytotron through whole life from May 21 to September 7 in 1999. Rice samples including brown rice, hull, stem and leaves were collected after harvest. The attached soils on root

were removed by washing with water. The soil samples were collected from Wagner's pots, air-dried and sieved to 2 mm.

Detection of PCDD/Fs was carried out by HRGC/HRMS method after soxhlet/solvent extraction and gel clean-up procedures. Seventeen native (Wellington Laboratories, Canada) and 13C 2,3,7,8-substituted isomers (Wellington Laboratories, Canada) were used as standard and isotope spike. Concentration of PCDD/Fs were determined by of HRGC(6890, Hewlett Packard, US) with a DB 17 column (J&W Scientific, US) and an SP 2331 column (Supelco, INC., US), connected to a HRMS (AutoSpec-Ultima, Micomass, UK) operation on a resolution of 10,000 using a positive electron ionization source and operating in the selected ion monitoring (SIM) mode. Verification of resolution in the working mass range was obtained by measuring perfluorokerosene (PFK) reference peaks. The current trap was 500 μA and the ionization energy was 30 eV. Ion source and injector temperatures were 260 °C.

**Results and Discussion**

Figure 1 shows the 2,3,7,8-chlorinated PCDD/Fs levels in soil samples. In all soil samples, the order of concentrations of the PCDD/Fs was OCDD >> 1,2,3,4,6,7,8-HpCDD > OCDF >> 1,2,3,4,6,7,8-HpCDF > 1,2,3,6,7,8-HxCDD > 2,3,4,6,7,8,9-HxCDF > 1,2,3,7,8,9-HxCDD > 1,2,3,7,8-PeCDD > 1,2,3,4,7,8-HxCDF, 1,2,3,4,7,8-HxCDD > 1,2,3,4,7,8,9-HpCDF, 1,2,3,6,7,8-HxCDF > 2,3,4,7,8-PeCDF, 1,2,3,7,8-PeCDF > 2,3,7,8-TCDD, 2,3,7,8-TCDF > 1,2,3,7,8,9-HxCDF. Among them, the concentration of OCDD, 1,2,3,4,6,7,8-HpCDD, and OCDF were about 10-1000 fold higher than other 2,3,7,8-chlorinated PCDD/Fs. Table 1 lists the 2,3,7,8-chlorinated PCDD/Fs levels in each part of rice plant. The observed

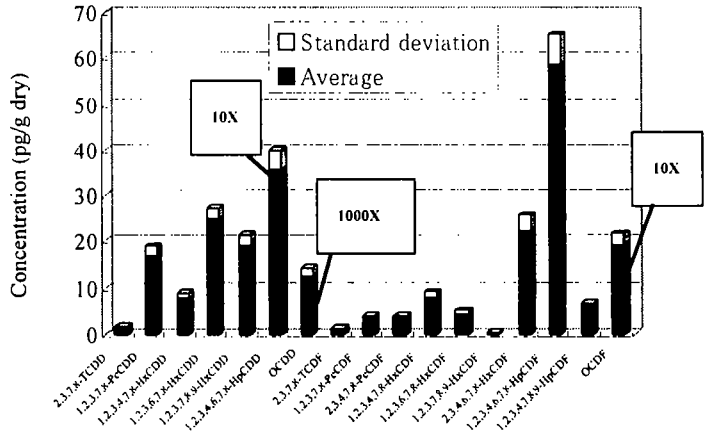


Fig. 1. 2,3,7,8-chlorinated PCDD/Fs levels in soil samples (n=7).

PCDD/Fs distribution patterns in rice root were very similar with the patterns in contaminated soil. This result is probably related to the strongly attached soil particles on rice root surface.

Table 1. 2,3,7,8-chlorinated PCDD/Fs levels in each part of rice plant

unit : pg/g wet

| *Congeners* | Brown rice 1 | Brown rice 2 | Hull 1 | Hull 2 | Leaves 1 | Leaves 2 | Stem 1 | Stem 2 | Root 1 | Root 2 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2,3,7,8-TCDD | n.d. | n.d. | n.d. | n.d. | 0.03 | 0.07 | n.d. | n.d. | n.d. | n.d. |
| 1,2,3,7,8-PeCDD | n.d. | n.d. | 0.02 | 0.03 | 0.13 | 0.38 | 0.01 | 0.02 | 0.93 | 1.3 |
| 1,2,3,4,7,8-HxCDD | n.d. | n.d. | 0.02 | 0.04 | 0.11 | 0.31 | n.d. | 0.03 | 0.40 | 0.54 |
| 1,2,3,6,7,8-HxCDD | n.d. | n.d. | 0.03 | 0.06 | 0.17 | 0.52 | 0.02 | 0.04 | 1.4 | 1.9 |
| 1,2,3,7,8,9-HxCDD | n.d. | n.d. | 0.03 | 0.04 | 0.14 | 0.40 | n.d. | 0.03 | 0.87 | 1.3 |
| 1,2,3,4,6,7,8-HpCDD | 0.04 | 0.05 | 0.25 | 0.49 | 0.92 | 3.1 | 0.09 | 0.21 | 15 | 20 |
| OCDD | 1.0 | 1.3 | 1.3 | 1.9 | 1.8 | 8.6 | 0.25 | 0.48 | 38 | 49 |
| 2,3,7,8-TCDF | n.d. | 0.01 | 0.03 | 0.05 | 0.17 | 0.48 | 0.03 | 0.05 | 0.05 | 0.08 |
| 1,2,3,7,8-PeCDF | n.d. | 0.01 | 0.06 | 0.10 | 0.39 | 1.1 | 0.04 | 0.09 | 0.20 | 0.24 |
| 2,3,4,7,8-PeCDF | n.d. | 0.01 | 0.06 | 0.12 | 0.29 | 0.90 | 0.03 | 0.06 | 0.20 | 0.24 |
| 1,2,3,4,7,8-HxCDF | n.d. | n.d. | 0.09 | 0.18 | 0.37 | 1.3 | 0.05 | 0.10 | 0.37 | 0.46 |
| 1,2,3,6,7,8-HxCDF | n.d. | n.d. | 0.09 | 0.18 | 0.41 | 1.3 | 0.04 | 0.10 | 0.21 | 0.29 |
| 1,2,3,7,8,9-HxCDF | n.d. | n.d. | n.d. | n.d. | n.d. | 0.04 | n.d. | n.d. | n.d. | n.d. |
| 2,3,4,6,7,8-HxCDF | n.d. | 0.02 | 0.18 | 0.37 | 0.50 | 1.9 | 0.05 | 0.12 | 1.1 | 1.6 |
| 1,2,3,4,6,7,8-HpCDF | 0.03 | 0.05 | 0.32 | 0.67 | 0.96 | 3.2 | 0.10 | 0.26 | 1.9 | 2.7 |
| 1,2,3,4,7,8,9-HpCDF | n.d. | n.d | 0.04 | 0.07 | 0.06 | 0.22 | n.d. | 0.02 | 0.20 | 0.29 |
| OCDF | n.d. | n.d. | 0.18 | 0.39 | 0.27 | 1.2 | n.d. | 0.11 | 5.3 | 7.5 |

*n.d. : not detected. ( 1: Koshihikari, 2: Fukuhatamochi)

The 2,3,7,8-chlorinated PCDD/Fs patterns in stem, leaves, hull and brown rice were not relevant for the patterns in soil, although the results of leaves and hull indicated that the OCDD was a slightly higher value than other congeners. Stem and brown rice covered by leaves and hull, these parts are not directly influenced by soil particles and atmospheric deposition. Therefore, the obtained data of stem and brown rice may be due to PCDD/Fs entry from soil. The order of PCDD/Fs concentrations was root >> leaves > hull > stem >> brown rice in rice plant. Especially, PCDD/Fs concentration of brown rice was negligible. It is thus apparent that the transfer of PCDD/Fs from contaminated soil into brown rice is not concerned, in the view of human consumption. The trends of I-TEQ levels in each part of rice plant are shown in Figure 2. The I-TEQ level of Fukuhatamochi was slightly higher value than the paddy rice, Koshihikari. It seems that reflected the different pathways of PCDD/Fs entry between Koshihikari and Fukuhatamochi.

Based on the obtained results, the transfer percentages of PCDFs in each part of rice plant (but not root) tended to be higher value than those of PCDDs. The results showed that PCDFs were more easily transferred from the contaminated soil into each part of rice than PCDDs.

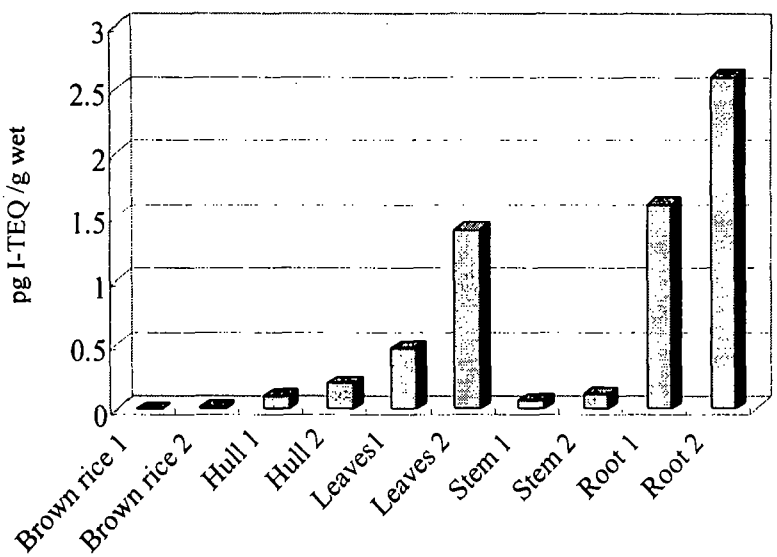


Fig. 2. I-TEQ levels in each part of rice plant.

(1: Koshihikari, 2: Fukuhatamochi)

**Acknowledgements**

This work was financially supported by Grants for Scientific Research by the Ministry of Agriculture, Forestry and Fisheries of Japan. The authors deeply thank Y. Ishii, Y. Kobara, S. Ishihara and K. Ito, National Institute for Agro-Environmental Sciences of Japan, for helpful discussions. We express our thanks to Japan Food Research Laboratories for PCDD/Fs analysis.

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