厦门大学环境与生态学院
College of the Environment & Ecology, Xiamen University

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Accumulation of perfluoroalkyl substances in lysimeter-grown rice in Japan

Eriko Yamazaki[1, 2], Sachi Taniyasu[2], Kosuke Noborio[3], Heesoo Eun[4], Pooja Thaker[5], Nirmal Kumar J. I.[5], Xinhong Wang[1], Nobuyoshi Yamashita[2]

[1] College of the Environment & Ecology, Xiamen University, China; [2] National Institute of Advanced Industrial Science and Technology (AIST), Japan; [3] Meiji University, Japan; [4] National Institute for Agro-Environmental Sciences, Japan; [5] Institute of Science & Technology for Advanced Studies & Research (ISTAR), India

INTRODUCTION

Perfluoroalkyl substances (PFAS) can persistently remain in water, soil, even in food, and seem to have potential threat to human health. Numerous food surveys have been conducted in the European Union and the United States. Nevertheless, there have been very few such investigations in Asia. One of the most important food crops in Asia is rice, but only one market survey (Wen-Ling et al., 2018) has been reported for it so far.

In this study, to elucidate PFAS kinetics in paddy fields, we grew rice (*Oryza sativa* indica 'IR40') in lysimeters irrigated with tap water (general cultivation system) or tap water with simulated contaminated water (SCW) (simulated exposure conditions) . The sectioned plant body, hulled rice, white rice, bran, paddy soil and irrigation water were analyzed for the residues of nineteen PFAS.

MATERIALS AND METHODS

Cultivation

Rice was cultivated by using two lysimeters. Normal cultivation used tap water for irrigation. In addition, a separate cultivation system used simulated contaminated water (SCW) for irrigation as a positive control (**Fig. 1**). In the SCW system, simulated contaminated water was applied 1 day before seedling transplantation. Thereafter, tap water was used to irrigate both lysimeters until harvest.

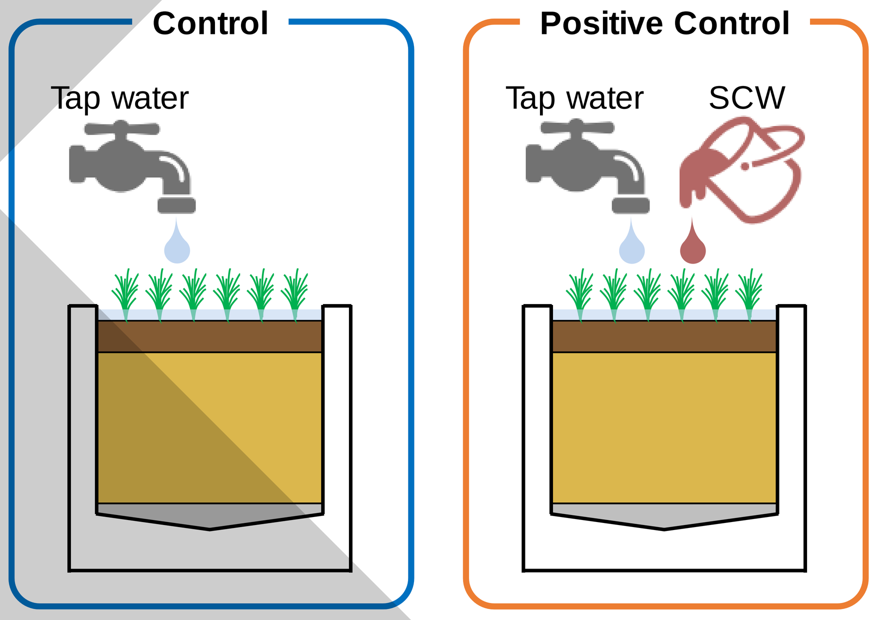

Fig. 1. Irrigation water of control and positive control lysimeter.

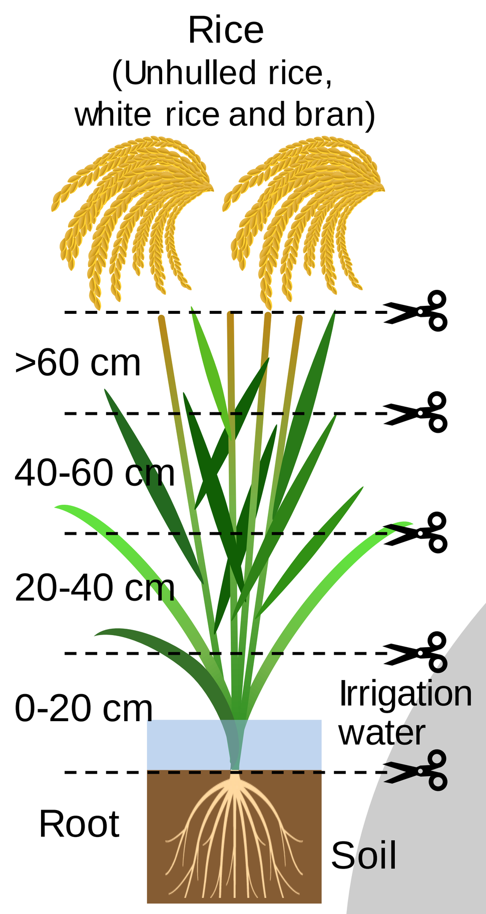

Fig. 2. Sample analyzed in this study.

Sampling

Intact soil samples were collected just before cultivation. Tap water was collected at an intermediate point during cultivation. Before analysis, the harvested rice plants were washed in distilled water to remove soil particles and air-dried at room temperature.

Sample analysis

The rice plants were sectioned into roots and stems including leaves at 0–20 cm, 20–40 cm, 40–60 cm and >60 cm (**Fig. 2**), unhulled rice, white rice and bran. The sectioned plant body, paddy soil and irrigation water were analyzed as described in **Fig. 3.**.

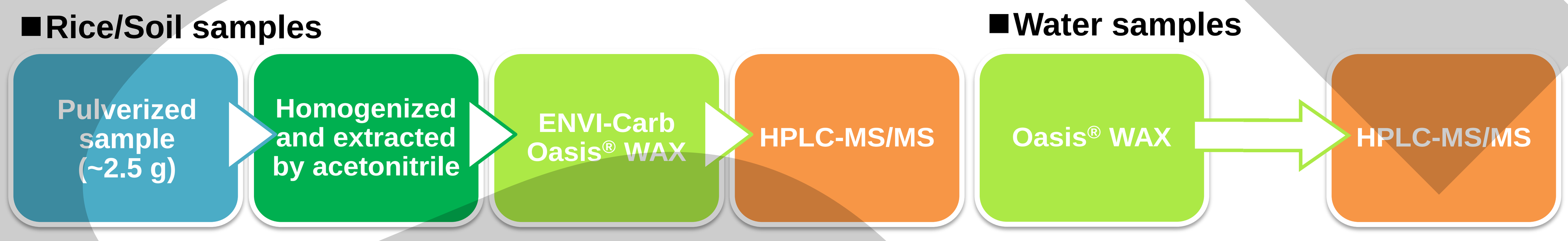

Fig. 3. Method flow for PFASs analysis in rice, soil and water samples.

RESULTS AND DISCUSSIONS

Control lysimeter

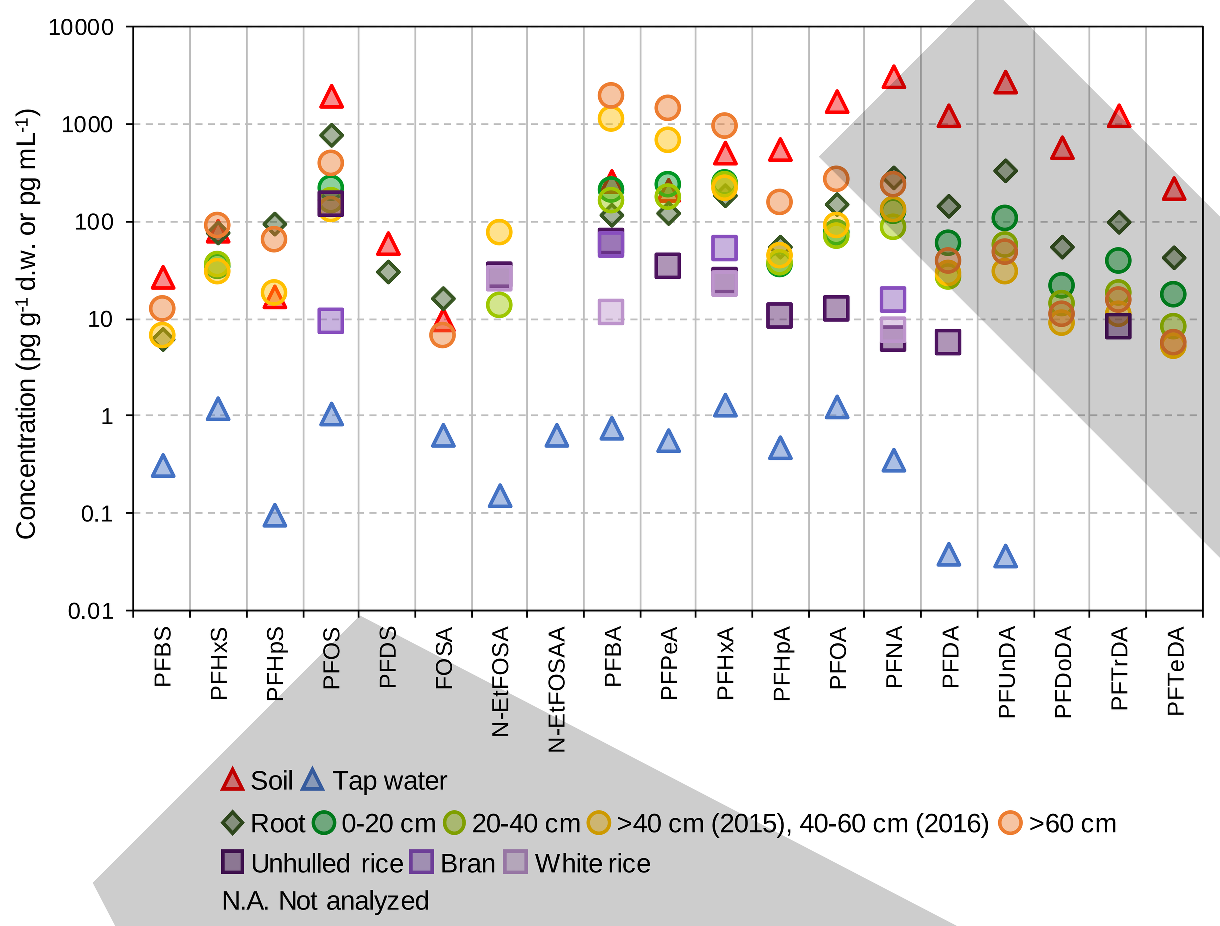

Fig. 4. Concentration of PFAS in soil (pg g-1 DW.), tap water (pg mL-1) and each portion of rice plant (pg g-1 DW) from lysimeter.

- The concentration in root and lower straw (0–20 cm) samples are similar to those in soil, especially for PFSAs and longer-chain PFCAs (C9–C14).

→ Continuous exposure of the root and lower straw (0–20 cm) to paddy field irrigation water may explain direct PFAS partition from the soil and irrigation water mixture.

- The PFCAs profile in higher straw (40–60 cm and >60 cm) remarkably differed from those in lower straw.
    - The >60 cm straw portion presented with 9–12 times more PFBA than the 0–20 cm and 20–40 cm portions. Nevertheless, the PFBA content in the >40 cm straw was only ~2 times that of the 20–40 cm section.
    - The same phenomenon was observed for PFPeA and PFHxA.

Positive control lysimeter

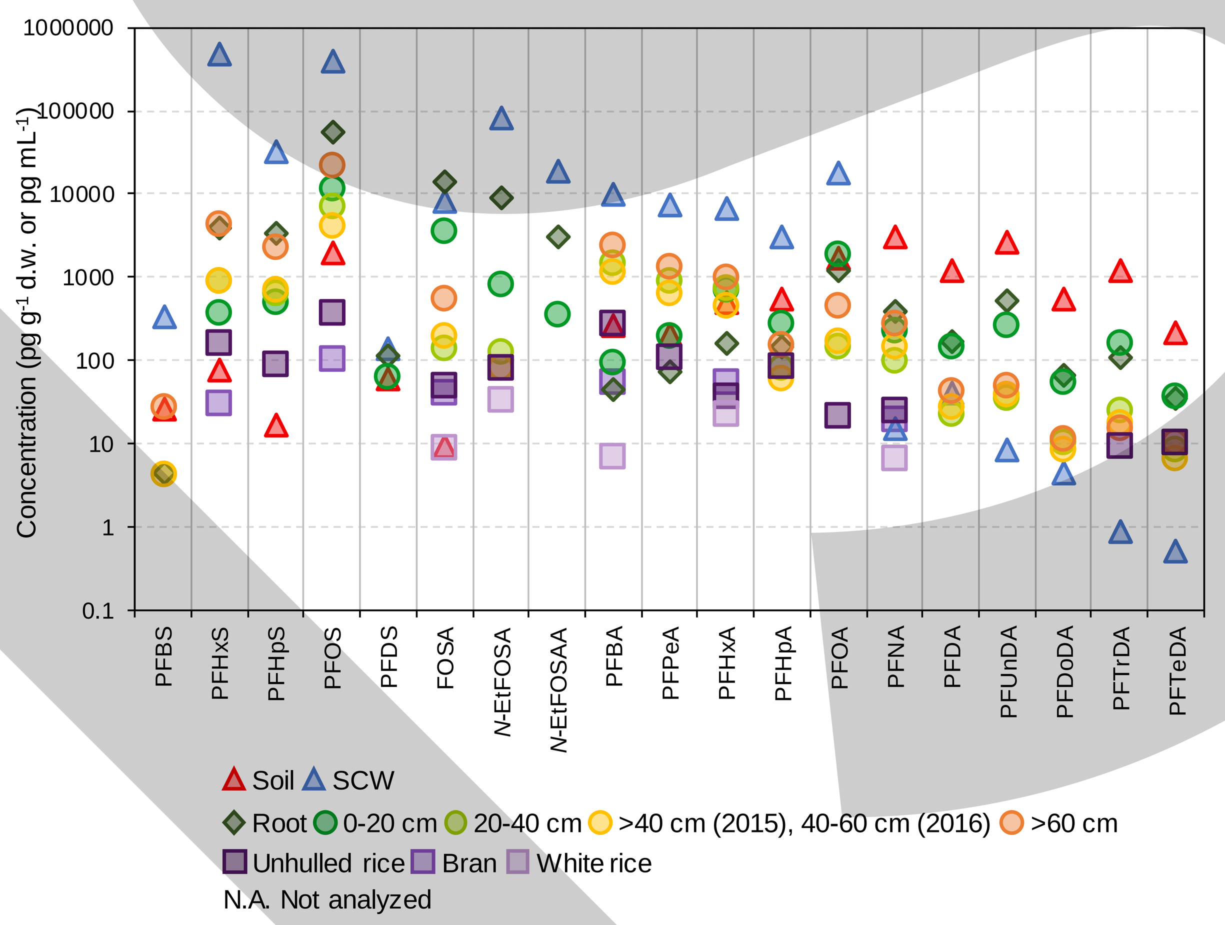

Fig. 5. Concentration of PFAS in soil (pg g-1 DW.), SCW (pg mL-1) and each portion of rice plant (pg g-1 DW) from lysimeter.

- The phenomenon observed in the SCW-free tap water experiment was dramatically more pronounced in the SCW experiment because of the relatively higher PFAS levels in the latter case.
- The concentrations of PFBA, PFPeA, and PFHxA were higher in the straw than the root.
- In contrast, the concentrations of PFHpA and the longer-chain PFAS (C7–C14) were not obviously higher in the straw than the root.
- The root and >60 cm straw showed similar concentrations of PFHxS and PFOS, whereas, the middle straw (40-60 cm) showed lower PFHxS and PFOS concentration among whole straw part.

PFAS concentrations in white rice, bran and unhulled rice

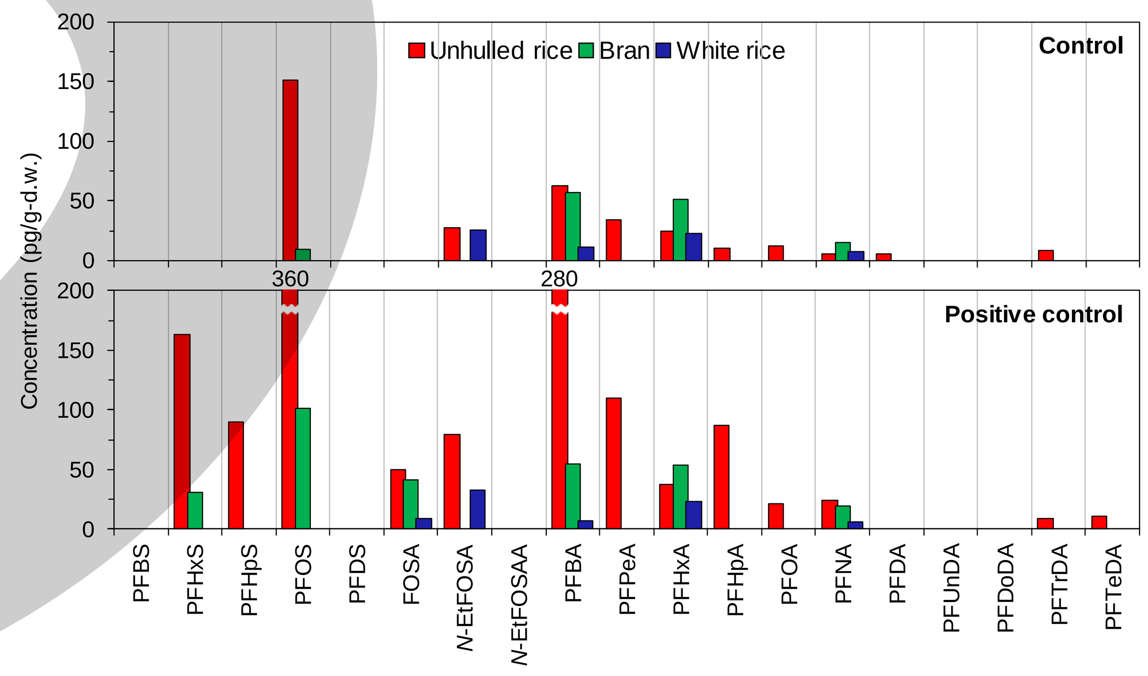

Fig. 6. Concentration of PFAS in rice harvested from control and positive control lysimeter.

- Remarkably higher PFAS concentrations were found in unhulled rice from plants exposed to SCW than in those exposed to tap water.
- PFAS concentration ratios (SCW + tap water / tap water only) in unhulled rice were much lower than the relative differences between the root and the higher straw concentrations indicated in **Fig. 4** and **5**.
- No significant differences in the concentration ratios were found in either bran or white rice exposed to tap water or SCW.

→ Substantial quantities of PFAS accumulated in the root, straw, unhulled rice and bran but relatively small amounts were transferred to the white rice.

CONCLUSION

✓ Compound specific accumulation of PFAS was found in rice plant (*Oryza sativa* subsp. indica) cultivated under normal and artificial condition.

✓ Although PFOS and PFOA were not detected in white rice, significant accumulation of PFAS were found in unhulled rice, rice bran, straw and root.

✓ Water solubility and partition to soil particle have important role of variable accumulation in rice plant.

REFERENCES

- Wen, B. et al., Field study on the uptake and translocation of perfluoroalkyl acids (PFAAs) by wheat (Triticum aestivum L.) grown in biosolids-amended soils. Environ. Pollut. 2014, 184, 547–554.
- ISO25101. Water quality. Determination of perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) — Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectroscopy; ISO/TC147/SC2/WG56; 2009.
- ISO/DIS21675. Water quality — Determination of polyfluorinated alkyl substances (PFAS) in water — Method using solid phase extraction and liquid chromatography-tandem mass spectrometry (LC-MS/MS); (revised in 2019).

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Contact address:
Eriko YAMAZAKI
e-yamazaki@xmu.edu.cn