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Study on the Environmentally Sound Management of Wastes Containing Newly Listed POPs

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Persistent Organic Pollutants (POPs) are a group of organic compounds that possess toxic properties, persist in the environment, bioaccumulate though the food web and pose a risk to human health and the environment. The Stockholm Convention on POPs entered into force in 2004, initially covering 12 chemicals. Since then the number of POPs has greatly increased. Currently a total of 30 POPs are listed in the Annexes of the Convention as of 2019.

Most of the newly listed POPs for global elimination are plastic additives such as brominated flame retardants (BFRs) and plasticizers including polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDs) which are added to a wide range of plastic products. However, even though their use has been phased out based on the Convention, special attention should be paid to their potential emission to the environment throughout the plastic lifecycle, especially during material recycling and disposal of end-of-life products, which will continue for a long time. Another major source of newly listed POPs-containing waste of concern in Japan is timber originating from old buildings, utility poles and cross-arms because a once common means of preserving wood was treatment with POPs such as pentachlorophenol (PCP) and pentachloronaphthalenes (PCNs), which were added to the Convention in 2015. PCNs are also produced unintentionally and some of the isomers have been confirmed to have dioxin-like toxicities but they are far from being fully understood. To address these issues, a series of studies was conducted during this three-year project to provide scientific information necessary for complying with the Convention in view of the listing of new substances, focusing on the management of wastes containing POPs in Japan.

(1) The PBDE and HBCD contents of end-of-life products were evaluated by investigating recyclable plastic resources, including shredded mixed plastics from waste electric and electronic equipment (WEEE), automobile shredder residues, and refuse-derived paper and plastics densified fuel (RPF) in Japan. WEEE-mix plastic has a higher potential risk of diffusing PBDEs as it tends to retain high levels of them. It is imperative to develop a practical on-site method to separate PBDE- and HBCD-containing plastic from non-POPs plastic in the dismantling stage to obtain POP-free plastic for material recycling. Based on case studies on BFR destruction experiments, we confirmed

controlled incineration with best available techniques as an appropriate treatment for waste containing BFRs.

(2) We measured the physicochemical properties of HBCD isomers and new BFRs (published as Kuribara et al., in press (Fig. 1), and Yui et al., 2018, respectively), and their volatilization flux from waste polystyrene insulation foams containing HBCDs. By combining an indoor fate model and experimental data on these properties and fluxes, we predicted the behavior of HBCDs in two actual recycling plants that manufacture RPF from waste insulation foams and other plastics as raw materials. The results showed that the method represented the actual behavior of HBCDs fairly. It should be useful for predicting HBCD emissions to the environment from recycling plants.

(3) We conducted the first survey in Japan on residue concentrations of POPs including chlordanes (CHLs), PCP and PCNs in waste timber and its recycled products (woodchip and particle board) (published as Koyano et al., 2019). In the recycled products, the highest concentrations were one to two orders lower than the low POP content (LPC) limits for the environmentally sound management of wastes defined under the Basel Convention (Fig. 2). Although none of the waste timber or recycled products had concentrations exceeding the LPC limits, one means of ensuring low POP concentrations in recycled products is to separate timber bearers from timber columns when demolishing wooden buildings.

(4) The unintentional formation and emission of PCNs during waste treatment processes was estimated using available data obtained through a sequence of waste incineration experiments using a lab-scale pilot plant and co-incineration experiments at 12 commercial-scale waste incineration facilities in Japan. Domestic unintentional emissions of PCNs to the atmosphere in FY 2014 were estimated to be 0.21–56 kg/y (incineration experiments) and 0.20–120 kg/y (investigations of incineration facilities). Unintentional emissions of PCNs to incineration residues were estimated to be 4.9–2300 kg/y.

(5) We characterized the dioxin-like activities of 42 PCNs and six technical PCN Halowax preparations by DR-CALUX assay using the rat hepatoma H4IIE cell line (published as Suzuki et al., in press). Of the 42 PCNs examined, 31 showed dioxin-like activities (Fig. 3), for which the mass-basis 2,3,7,8-TCDD-relative potencies (REPs) of some of the PCNs were equal to or exceeded the WHO-TEFs or REPs of dioxins such as OCDD and OCDF. Based on a comparison of theoretical and experimental TCDD-EQs, we found that our REP-based approach would be particularly useful in the risk management of unintentionally generated PCNs in emission gases because it could help elucidate the contribution of dioxin-like PCNs to the overall dioxin-like toxicity of emission gases.

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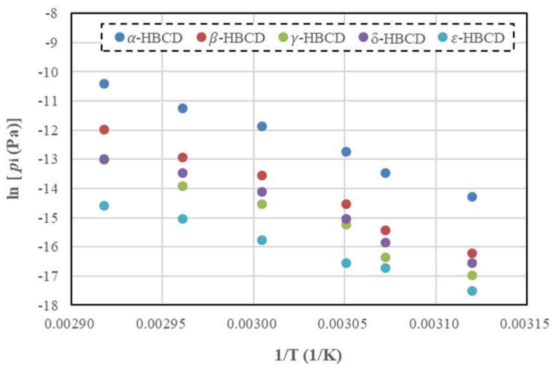

Fig. 1 Vapor pressures (p_i) of HBCD isomers. Cited from Kuribara *et al.* (in press).

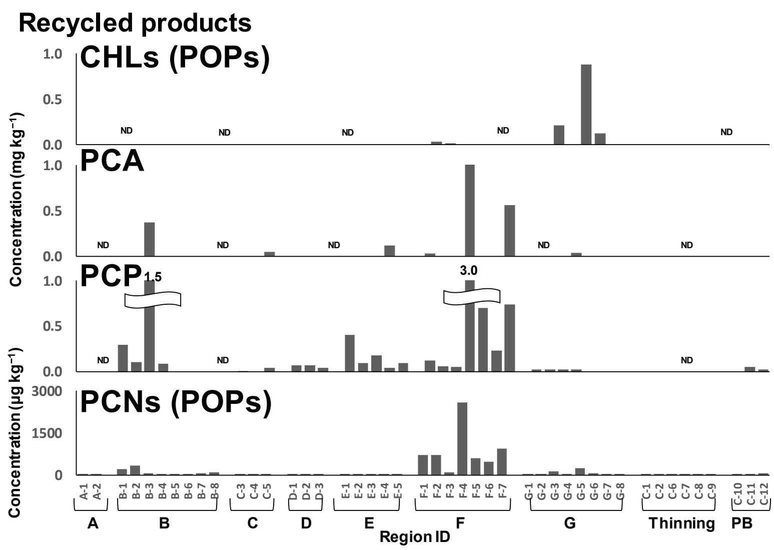

Fig. 2 Spatial distribution of chlordane (CHLs), pentachlorophenol (PCP) and pentachloronaphthalenes (PCNs) concentrations detected in recycled woodchip and particle board (PB) collected in Japan. CHLs: sum of trans- and cis-chlordane; PCNs: sum of di- to octa-CNs;

thinning: wood from the thinning and pruning of trees; ND: not detected. Cited from Koyano *et al.* (2019).

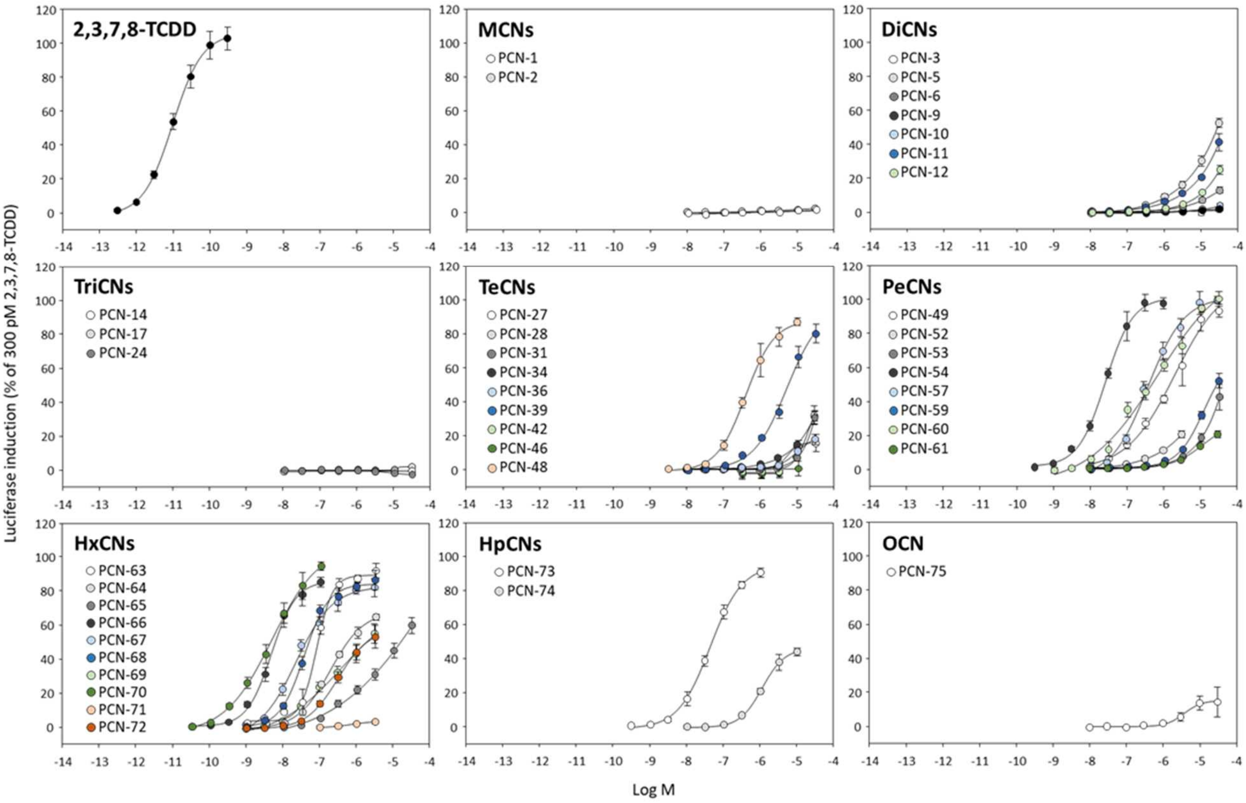

Fig. 3 Dose–response for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) and 42 polychlorinated naphthalenes, as determined by DR-CALUX assay (n = 3).
CNs, chlorinated naphthalenes; M, mono-; Di, di-; Tri, tri-; Te, tetra-; Pe, penta-; Hx, hexa-; Hp, hepta-; O, octa-. Cited from Suzuki *et al* (in press).