Evaluation of dioxin-like activities in settled house dust from vietnamese e-waste recycling sites: Relevance of polychlorinated/brominated dibenzo- p -dioxin/furans and dioxin-like PCBs

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Abstract: Few studies have investigated the human exposure to the ensemble of dioxin-related compounds (DRCs) released from uncontrolled e-waste recycling, especially from a toxic effect standpoint. This study evaluated the TCDD toxic equivalents (TEQs) in persistent extracts of settled house dust from two Vietnamese e-waste recycling sites (EWRSs) using the Dioxin-Responsive Chemically Activated LUciferase gene eXpression assay (DR-CALUX), combined with chemical analysis of PCDD/Fs, DL-PCBs, PBDD/Fs, and monobromo PCDD/Fs to determine their TEQ contribution. The CALUX-TEQ levels in house dust ranged from 370 to 1000 pg g^{-1} in the EWRSs, approximately 3.5-fold higher than in the urban control site. In EWRS house dust, the concentrations of the unregulated PBDFs were 7.7-63 ng g^{-1}, an order of magnitude higher than those of regulated DRCs (PCDD/Fs and DL-PCBs), and PBDFs were also principal CALUX-TEQ contributors (4.2-22%), comparable to PCDD/Fs (8.1-29%). The CALUX-TEQ contribution of DRCs varied, possibly depending on thermal processing activities (higher PCDD/F-TEQs) and PBDE content in the waste (higher PBDF-TEQs). However, the percentage of unknown dioxin-like activities was high in all dust samples, indicating large contribution from unidentified DRCs and/or synergy among contaminants. Estimates of TEQ intake from dust ingestion suggest that children in the EWRSs may be adversely affected by DRCs from dust.

Index Keywords: Chemically activated LUciferase gene expressions; Control sites; Dioxin-like PCBs; Dl-PCBs; Dust ingestion; Dust samples; e-Waste; House dust; Human exposures; Order of magnitude; PCDD/Fs; Related compounds; Thermal processing; Toxic effect; Toxic Equivalents TEQ; Chemical analysis; Gene expression; Houses; Polychlorinated biphenyls; Recycling; Toxic materials; Wastes; Dust; dioxin; polybrominated dibenzofuran; polychlorinated biphenyl; polychlorinated dibenzodioxin; chemical analysis; gene expression; health risk; industrial emission; ingestion rate; particulate matter; PCB; PCDD; pollution exposure; recycling; toxicity; article; chemical analysis; dioxin responsive chemically activated luciferase gene expression assay; genetic analysis; house dust; recycling; thermal analysis; urban area; Viet Nam; Viet Nam

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References:

- http://www.grid.unep.ch/product/publication/download/ew_ewaste.en.pdf, E-waste, the hidden side of IT equipment's manufacturing and use, 2005Wong, M.H., Wu, S.C., Deng, W.J., Yu, X.Z., Luo, Q., Leung, A.O.W., Wong, C.S.C., Wong, A.S., Export of toxic chemicals. A review of the case of uncontrolled electronic-waste recycling (2007) Environ. Pollut., 149, pp. 131-140
- Zhao, G., Xu, Y., Li, W., Han, G., Ling, B., PCBs and OCPs in human milk and selected foods from Luqiao and Pingqiao in Zhejiang, China (2007) Sci. Total Environ., 378, pp. 281-292
- Bi, X.H., Thomas, G.O., Jones, K.C., Qu, W.Y., Sheng, G.Y., Martin, F.L., Fu, J.M., Exposure of electronics dismantling workers to polybrominated diphenyl ethers, polychlorinated biphenyls, and organochlorine pesticides in South China (2007) Environ. Sci. Technol., 41, pp. 5647-5653
- Tue, N.M., Sudaryanto, A., Minh, T.B., Isobe, T., Takahashi, S., Viet, P.H., Tanabe, S., Accumulation of polychlorinated biphenyls and brominated flame retardants in breast milk from women living in Vietnamese e-waste recycling sites (2010) Sci. Total Environ., 408, pp. 2155-2162
- Leung, A.O.W., Luksemburg, W.J., Wong, A.S., Wong, M.H., Spatial distribution of polybrominated diphenyl ethers and polychlorinated dibenzo- p -dioxins and dibenzofurans in soil and combusted residue at Guiyu, an electronic waste recycling site in Southeast China (2007) Environ. Sci. Technol., 41, pp. 2730-2737
- Ma, J., Kannan, K., Cheng, J., Horii, Y., Wu, Q., Wang, W., Concentrations, profiles, and estimated human exposures for polychlorinated dibenzo- p -dioxins and dibenzofurans from electronic waste recycling facilities and a chemical industrial

complex in Eastern China (2008) Environ. Sci. Technol., 42, pp. 8252-8259

- Hanari, N., Kannan, K., Okazawa, T., Kodavanti, P.R.S., Aldous, K.M., Yamashita, N., Occurrence of polybrominated biphenyls, polybrominated dibenzo- p -dioxins, and polybrominated dibenzofurans as impurities in commercial polybrominated diphenyl ether mixtures (2006) Environ. Sci. Technol., 40, pp. 4400-4405
- Watanabe, I., Sakai, S., Environmental release and behavior of brominated flame retardants (2003) Environ. Int., 29, pp. 665-682
- Weber, R., Kuch, B., Relevance of BFRs and thermal conditions on the formation pathways of brominated and brominated-chlorinated dibenzodioxins and dibenzofurans (2003) Environ. Int., 29, pp. 699-710
- Kajiwara, N., Noma, Y., Takigami, H., Photolysis studies of technical decabromodiphenyl ether (DecaBDE) and ethane (DeBDethane) in plastics under natural sunlight (2008) Environ. Sci. Technol., 42, pp. 4404-4409
- Behnisch, P.A., Hosoe, K., Sakai, S., Combinatorial bio/chemical analysis of dioxin and dioxin-like compounds in waste recycling, feed/food, humans/wildlife and the environment (2001) Environ. Int., 27, pp. 495-519
- Van Leeuwen, F.X.R., Feeley, M., Schrenk, D., Larsen, J.C., Farland, W., Younes, M., Dioxins: WHO's tolerable daily intake (TDI) revisited (2000) Chemosphere, 40, pp. 1095-1101
- Ma, J., Addink, R., Yun, S., Cheng, J., Wang, W., Kannan, K., Polybrominated dibenzo- p -dioxins/dibenzofurans and polybrominated diphenyl ethers in soil, vegetation, workshop-floor dust, and electronic shredder residue from an electronic waste recycling facility and in soils from a chemical industrial complex in Eastern China (2009) Environ. Sci. Technol., 43, pp. 7350-7356
- Zennegg, M., Yu, X., Wong, M.H., Weber, R., Fingerprints of chlorinated, brominated and mixed halogenated dioxins at two e-waste recycling sites in Guiyu/China (2009) Organohalogen Compd., 71, pp. 2248-2252
- Suzuki, G., Takigami, H., Nose, K., Takahashi, S., Asari, M., Sakai, S., Dioxin-like and transthyretin-binding compounds in indoor dusts collected from Japan: Average daily dose and possible implications for children (2007) Environ. Sci. Technol., 41, pp. 1487-1493
- (2004) Analyse, Review and Control of Results Obtained by the DR CALUX Bioassay, , Pe-BDS-007
- BioDetection Systems: Amsterdam, The Netherlands
- (2005) Method for Determination of Tetra-through Octachlorodibenzo-p-Dioxins, Tetrathrough Octachlorodibenzofurans and Dioxin-Like Polychlorinatedbiphenyls in Industrial Water and Waste Water, , JIS K0312
- Japanese Industrial Standard
- Takahashi, S., Sakai, S., Watanabe, I., An intercalibration study on organobromine compounds: Results on polybrominated diphenylethers and related dioxin-like compounds (2006) Chemosphere, 64, pp. 234-244
- Van Den Berg, M., The 2005 World Health Organization reevaluation of human and mammalian toxic equivalency factors for dioxins and dioxin-like compounds (2006) Toxicol. Sci., 93, pp. 223-241
- Saito, K., Takekuma, M., Ogawa, M., Kobayashi, S., Sugawara, Y., Ishizuka, M., Nakazawa, H., Matsuki, Y., Extraction and cleanup methods of dioxins in house dust from two cities in Japan using accelerated solvent extraction and a disposable multi-layer silicagel cartridge (2003) Chemosphere, 53, pp. 137-142
- Hong, B., Garabrant, D., Hedgeman, E., Demond, A., Gillespie, B., Chen, Q., Chang, C., Adriaens, P., Impact of WHO 2005 revised toxic equivalency factors for dioxins on the TEQs in serum, household dust and soil (2009) Chemosphere, 76, pp. 727-733
- Takigami, H., Suzuki, G., Hirai, Y., Sakai, S., Brominated flame retardants and other polyhalogenated compounds in indoor air and dust from two houses in Japan (2009) Chemosphere, 76, pp. 270-277
- Baker, J.I., Hites, R.A., Is combustion the major source of polychlorinated dibenzo- p -dioxins and dibenzofurans to the

environment? A mass balance investigation (2000) Environ. Sci. Technol., 34, pp. 2879-2886

- Minh, N.H., Minh, T.B., Watanabe, M., Kunisue, T., Monirith, I., Tanabe, S., Sakai, S., Prudente, M.S., Open dumping site in Asian developing countries: A potential source of polychlorinated dibenzo- p -dioxins and polychlorinated dibenzofurans (2003) Environ. Sci. Technol., 37, pp. 1493-1502
- Wang, L., Chang-Chien, G., Characterizing the emissions of polybrominated dibenzo- p -dioxins and dibenzofurans from municipal and industrial waste incinerators (2007) Environ. Sci. Technol., 41, pp. 1159-1165
- Tue, N.M., Suzuki, G., Isobe, T., Takahashi, S., Viet, P.H., Tanabe, S., Levels of polychlorinated biphenyls, brominated flame retardants and dioxin-like activities associated with e-waste recycling in Vietnamese house dust (2009) Organohalogen Compd., 71, pp. 368-371
- Sakai, S., Watanabe, J., Honda, Y., Takatsuki, H., Aoki, I., Futamatsu, M., Shiozaki, K., Combustion of brominated flame retardants and behavior of its byproducts (2001) Chemosphere, 42, pp. 519-531
- Takasuga, T., Senthilkumar, K., Matsumura, T., Shiozaki, K., Sakai, S., Isotope dilution analysis of polychlorinated biphenyls (PCBs) in transformer oil and global commercial PCB formulations by high resolution gas chromatography-high resolution mass spectrometry (2006) Chemosphere, 62, pp. 469-484
- Behnisch, P.A., Hosoe, K., Sakai, S., Brominated dioxin-like compounds: In vitro assessment in comparison to classical dioxin-like compounds and other polyaromatic compounds (2003) Environ. Int., 29, pp. 861-877
- Olsman, H., Engwall, M., Kammann, U., Klempt, M., Otte, J., Van Bavel, B., Hollert, H., Relative differences in aryl hydrocarbon receptor-mediated response for 18 polybrominated and mixed halogenated dibenzo- p -dioxins and -furans in cell lines from four different species (2007) Environ. Toxicol. Chem., 26, p. 2448
- Hagberg, J., Olsman, H., Van Bavel, B., Engwall, M., Lindström, G., Chemical and toxicological characterisation of PBDFs from photolytic decomposition of decaBDE in toluene (2006) Environ. Int., 32, pp. 851-857
- Horii, Y., Khim, J.S., Higley, E.B., Giesy, J.P., Ohura, T., Kannan, K., Relative potencies of individual chlorinated and brominated polycyclic aromatic hydrocarbons for induction of aryl hydrocarbon receptor-mediated responses (2009) Environ. Sci. Technol., 43, pp. 2159-2165
- Bannister, R., Safe, S., Synergistic interactions of 2, 3, 7, 8-TCDD and 2, 2′, 4, 4′, 5, 5′-hexachlorobiphenyl in C57BL/6J and DBA/2J mice: Role of the Ah receptor (1987) Toxicology, 44, pp. 159-169
- Suzuki, G., Takigami, H., Kushi, Y., Sakai, S., Evaluation of mixture effects in a crude extract of compost using the CALUX bioassay and HPLC fractionation (2004) Environ. Int., 30, pp. 1055-1066
- Jones-Otazo, H.A., Clarke, J.P., Diamond, M.L., Archbold, J.A., Ferguson, G., Harner, T., Richardson, G.M., Wilford, B., Is house dust the missing exposure pathway for PBDEs? An analysis of the urban fate and human exposure to PBDEs (2005) Environ. Sci. Technol., 39, pp. 5121-5130
- Liem, A., Fürst, P., Rappe, C., Exposure of populations to dioxins and related compounds (2000) Food Addit. Contam., 17, pp. 241-259
- Llobet, J.M., Martí-Cid, R., Castell, V., Domingo, J.L., Significant decreasing trend in human dietary exposure to PCDD/PCDFs and PCBs in Catalonia, Spain (2008) Toxicol. Lett., 178, pp. 117-126
- Lorber, M., Patterson, D., Huwe, J., Kahn, H., Evaluation of background exposures of Americans to dioxin-like compounds in the 1990s and the 2000s (2009) Chemosphere, 77, pp. 640-651
- http://www.cdc.gov/growthcharts/, CDC, Growth charts for 2-5 year old, 2002