The impact of polybrominated diphenyl ethers in the classroom dust on the health of the elementary school's children

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Polybrominated diphenyl ethers (PBDEs) are a class of brominated fire retardants (BFRs) and man-made non-naturally occurring chemicals to be recognized as endocrine disruptors. PBDEs have been utilized extensively as additives in a wide variety of consumer products, such as electronic devices, vehicles, building materials, textiles, carpets, and furniture foam and upholstery in these three decades. PBDEs are ubiquitous in the terrestrial and aquatic environment to bioaccumulate in the plants and animals due to their environmental and biological persistence (Chokwe *et al.* 2015, Wang *et al.* 2015).

The negative effects of human staying indoors are numerous including the plenty of hazardous pollutants like PBDEs. Levels of PBDEs are much lower in outdoor than indoor air and that the source of BFRs outdoors may be indoor air (Newton *et al.* 2015). Humans tend to spend more time indoors than outdoors, so direct PBDEs exposure is a public health concern. Recently, it is demonstrated that most PBDEs exposures are from indoor dust and not food (Kang *et al.* 2011).

Dust samples were collected in 10 urban elementary schools in southern Taiwan from September 2014 to February 2015. Classroom dust was collected by a vacuum cleaner. After the procedure of extraction, cleanup, and concentration, the final extract including fourteen PBDEs (BDE-28, 47, 49, 99, 100, 153, 154, 183, 196, 197, 203, 207, 208, and 209) was analyzed by high resolution gas chromatograph with high resolution mass spectrometry. The health assessment of the elementary school children in houses was including daily intake (DI), non-cancer (hazard index, HI), and cancer (R) risks. The risk parameters were supported by the US EPA Integrated Risk Information System (IRIS) (US EPA, 2015a), Exposure factors handbook (US EPA, 2015b), and the report of the Nutrition and Health Survey in Taiwan (NAHSIT) from the Health Promotion Administration of Ministry of Health and Welfare in Taiwan, between 2005 and 2008 (National Health Research Institute, 2015) .

Dust Σ_{14}PBDE levels in the classrooms of the elementary schools with mean and standard deviation (SD) (n=10) were 370 and 65.8 ng/g, respectively. BDE-209 was the predominant congener among 14 BDE congeners in most of dust samples to show mean±SD and the percentage composition as 263±46.9 (70.1%). Non-dietary daily intakes of BDE-47, 99, 153, and 209 for the school-age children via classroom dust in the elementary schools were $7.74\text{x}10^{-10}$, $1.53\text{x}10^{-10}$, $6.97\text{x}10^{-10}$, and $1.94\text{x}10^{-8}$ mg/kg/day, respectively. Non-cancer risks (HQs) for school children were below the critical values of 1.00 (BDE-47: $1.60\ \text{x}10^{-7}$; BDE-99: $3.15\ \text{x}10^{-7}$; BDE-153: $7.20\ \text{x}10^{-8}$; BDE-209: $5.73\ \text{x}10^{-8}$). Only BDE-209 among 209 BDEs could be assessed for the cancer risk. The cancer risk from the non-dietary exposure pathway for Taiwanese children in the elementary schools were lower than the threshold ($R=1\times10^{6}$). The findings of the present study showed that the classroom dust concentrations of PBDEs in the elementary schools were harmful for the school-age children in Taiwan after the health risks of the children were assessed based on our results.

Table 1. Heath risks for school children in the classrooms of the elementary schools.

PBDEs	Health risk		
	DI (mg/kg/day)	HQ	R
BDE-47	$7.74\text{x}10^{-10}$	$1.60\text{x}10^{-7}$	-
BDE-99	$1.53\ \text{x}10^{-10}$	$3.15\ \text{x}10^{-7}$	-
BDE-153	$6.97\ \text{x}10^{-10}$	$7.20\ \text{x}10^{-8}$	-
BDE-209	$1.94\ \text{x}10^{-8}$	$5.73\ \text{x}10^{-8}$	$2.81\text{x}10^{-13}$

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