

## **Volatile organic compounds (VOC), formaldehyde and nitrogen dioxide (NO<sub>2</sub>) in schools in Johor Bahru, Malaysia: Associations with rhinitis, ocular, throat and dermal symptoms, headache and fatigue**

### **ABSTRACT**

This paper studied associations between volatile organic compounds (VOC), formaldehyde, nitrogen dioxide (NO<sub>2</sub>) and carbon dioxide (CO<sub>2</sub>) in schools in Malaysia and rhinitis, ocular, nasal and dermal symptoms, headache and fatigue among students. Pupils from eight randomly selected junior high schools in Johor Bahru, Malaysia (N = 462), participated (96%). VOC, formaldehyde and NO<sub>2</sub> were measured by diffusion sampling (one week) and VOC also by pumped air sampling during class. Associations were calculated by multi-level logistic regression adjusting for personal factors, the home environment and microbial compounds in the school dust. The prevalence of weekly rhinitis, ocular, throat and dermal symptoms were 18.8%, 11.6%, 15.6%, and 11.1%, respectively. Totally 20.6% had weekly headache and 22.1% fatigue. Indoor CO<sub>2</sub> were low (range 380–690 ppm). Indoor median NO<sub>2</sub> and formaldehyde concentrations over one week were 23 µg/m<sup>3</sup> and 2.0 µg/m<sup>3</sup>, respectively. Median indoor concentration of toluene, ethylbenzene, xylene, and limonene over one week were 12.3, 1.6, 78.4 and 3.4 µg/m<sup>3</sup>, respectively. For benzaldehyde, the mean indoor concentration was 2.0 µg/m<sup>3</sup> (median < 1 µg/m<sup>3</sup>). Median indoor levels during class of benzene and cyclohexane were 4.6 and 3.7 µg/m<sup>3</sup>, respectively. NO<sub>2</sub> was associated with ocular symptoms (p < 0.001) and fatigue (p = 0.01). Formaldehyde was associated with ocular (p = 0.004), throat symptoms (p = 0.006) and fatigue (p = 0.001). Xylene was associated with fatigue (p < 0.001) and benzaldehyde was associated with headache (p = 0.03). In conclusion, xylene, benzaldehyde, formaldehyde and NO<sub>2</sub> in schools can be risk factors for ocular and throat symptoms and fatigue among students in Malaysia. The indoor and outdoor levels of benzene were often higher than the EU standard of 5 µg/m<sup>3</sup>.

**Keyword:** Volatile organic compounds (VOC); Formaldehyde; Nitrogen dioxide (NO<sub>2</sub>); School environment; Sick building syndrome (SBS); Rhinitis