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Use of a sensory irritation potential index to characterize improvement indoor air quality in French schools by ventilation

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ABSTRACT
After several cases of health problems in French schools, a methodology for health risk assessment related to indoor air quality (IAQ) was required. Based on measured concentrations in schools where acute symptoms possibly due to exposure to airborne sensory irritants were reported, an index quantifying the sensory irritation potential was built and used. This paper focuses on one classroom where the index was successively applied without any ventilation system, after the implementation of passive ventilation grids and with a mechanically controlled ventilation. The decrease of the index value was correlated with an improved IAQ perception by pupils and teachers since no complaint occurred any longer. It shows the ventilation efficiency in removing irritating volatile organic compounds (VOCs) and the validity of our IAQ irritant potential index.

INDEX TERMS
School; Ventilation; VOCs; Irritation potential index

INTRODUCTION
IAQ in schools is a topic that stimulates a lot of national research programs. Not only scientific attention, but also parents and school administrators' preoccupation grew in recent years. Children belong to a susceptible group of population and bad IAQ can influence learning capacities (US-EPA, 2003). It is thus necessary to assess IAQ with both building inspection and relevant air sampling in order to explain complaints typical of sick building syndrome, avoid them and in the end guarantee a healthy and comfortable indoor environment. With this aim, we used an IAQ irritant potential index.

METHODS
Location
Strong headaches, breathing difficulties, and nose bleeding were regularly reported by pupils and teachers in a French school in Autumn 2001. Approximately 300 children (9–11 years old) and 10 adults used to come four days a week. The building (one floor, 1000 m^2) consists of a hall, 11 classrooms and one office constructed three months before on a site without industrial history. It is located in a residential area of a small French city. At the end of a dead end street with very little traffic, the building is surrounded by houses and another school with school yard, where people, teachers and pupils did not complain about similar symptoms. There was no ventilation system at the beginning of the study.

After a careful building inspection with regard to potential chemical and biological emission sources (furniture, household products, water damage), no relevant sources were clearly identified. VOCs, aldehydes and ketones measurements were thus done.

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Sampling and Analyses

Active sampling devices (Sep-pack® cartridges) were used to trap aldehydes and ketones. After sampling, the cartridges were extracted with 2 ml acetonitrile. The extracts were analysed with HPLC separation (KROMASIL C18 150 mm–3 mm–3.5 urn) and UV detection (λ= 365 nm). VOCs were trapped with active device on a sorption tube (Carbotrap®) and analysed by thermodesorption (350°C during 5 min) and GC-MS (column DB30, 30 m) or GC coupled with FID. As relative humidity (RH) may play a role in eye, nose, and airway irritation, RH and temperature were hence measured.

The samplers were limited to one classroom where symptoms were mostly described. In this unoccupied classroom, the first series of measurements took place in January 2002 (C1 in Table 1). the second after the installation of two passive ventilation grids (10 × 5 cm) in March 2002 (C2 in Table 1), and the last one after the implementation of mechanically controlled ventilation in May 2002 (C3 in Table 1). In this latter experiment phase, sampling was also conducted with 26 pupils and two adults in the classroom to assess the impact of human presence on results (not reported in Table 1).

Sensory Irritation Potential Index

A weighted sum parameter for sensory irritation (Eqn 1) was used to evaluate IAQ. The general approach for the development of such an IAQ index has been previously used (Ten Brinke *et al.*, 1998; Meininghaus *et al.*, 2002, 2003) and is, therefore, only briefly described.

When assessing the risk of compounds with regard to their health effects, their concentrations are compared to toxicological reference values (TRV), which in turn, are often derived from animal studies by including safety factors. If the concentration of a target compound remains below its TRV, the risk of developing corresponding health effects is considered to be negligible. In the present study, TRV are selected or developed based on the symptoms of sensory irritation by inhalation. Since no specific IAQ guideline values exist, either existing TRV for ambient air are selected or TRV from IAQ literature are proposed (WHO, 2000; ATSDR; Nielsen *et al.*, 1996). When no international or national guideline value is available, tentative guideline values are developed on the basis of toxicological data such as RD_{50}, i.e. the concentration inducing a 50 % decrease in respiratory rate in mice.

When assuming additivity of sensory irritation (Flemming *et al.*, 1996), a weighted sum parameter (Eqn (1)) may be used to assess the summed effect of sensory irritants. Here, the concentration of a potential sensory irritant is divided by its corresponding TRV:

$$S = \sum_i \frac{C_i}{TRV_i} \qquad (1)$$

If S remains below 1, it may be reasonable to assume that the risk of developing the irritant effects following inhalation of the studied mixture is not likely.

RESULTS

The main identified pollutant concentrations are reported in Table 1. Table 2 summarizes the different S sums calculated.

Table 1 Indoor air concentrations (µg/m³) measured in the same unoccupied classroom

	C1 (without ventilation)	C2 (passive ventilation)	C3 (mechanical ventilation)	Toxicological reference value (µg/m³)
Formaldehyde	50.3	35.8	16.6	100(WHO)
Acetaldehyde	28.4	16.2	37.8	5000 (RD_{50})
Acetone	656	57.1	26.3	77,000 (RD_{50})
Toluene	93.6	38.6	34	1000 (OMS)
Xylenes	1 015	326	97	4400 (ATSDR)
Ethylbenzene	195	85	26	8000 (RD_{50})
Butyl acetate	198	35.7	10	2600 (RD_{50})
2-Ethylhexanol	124	43	21	180 (RD_{50})

'RD_{50}' reference indicates that the approach based on RD_{50} and described by (Nielsen *et al.*, 1996; Meininghaus *et al.*, 2002) is used.

Table 2 Sensory irritation potential index S in 3 ventilation configurations

	Without ventilation	Passive ventilation	Mechanical ventilation
S index	2.05	0.78	0.32

DISCUSSION

Measured concentrations confirm that studied indoor air contains a mixture of pollutants without particularly high indoor levels. No specific pollutant can be proposed as responsible for irritation symptoms. Each of these chemical compounds is present in a typical range of indoor concentrations considering comparable data from recent literature (Gonzalez-Flesca *et al.*, 1999; Ulrich *et al.*, 1999; Meininghaus *et al.*, 2001; Smedge, 2001). Moreover, each of them, considered separately, is below its TRV for acute sensory irritation effect following inhalation.

However, when looking at the mixture of studied compounds, different results are obtained since the risk of developing sensory irritation is not negligible when no ventilation system is present. As soon as ventilation was installed, complaints disappeared slowly and S fell below 1. IAQ is clearly improved with passive ventilation grids, and even better with mechanically controlled ventilation. Ventilation systems as a solution to improve IAQ were installed since no alternative aiming at reducing the responsible pollutant emissions could be suggested (new furniture, new flooring material, end of one product use).

One of the limits of the proposed index is that the sampling strategy is based on the assumption that measured concentrations are representative of levels to which all individuals are exposed at all times in the classroom, which is not necessarily the case.

CONCLUSION

The health risk assessment of airborne irritants detected in the school indoor air using the sensory irritation potential index allows us to appreciate global IAQ when no specific pollution can be identified. The evolution of S index shows that the index might be reliable to estimate IAQ irritant potential, and that ventilation is a good way to improve IAQ when sources cannot clearly be identified and immediately removed.

The index should be refined with measurement and characterization of the irritating potential of other pollutants, for example, particles, fibres, microbiological pollutants, reactive compounds.

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REFERENCES

ATSDR, Agency for Toxic Substances and Disease Registry, Atlanta, USA (http://www.atsdr.cdc.gov).

Flemming, R.C., Arts, J.H.E.. Groten, J.P. and Feron, V.J. (1996). Sensory irritation to mixtures of formaldehyde, acrolein, and acetaldehyde in rats. *Archives of Toxicology*, 70. 329-337.

Gonzalez-Flesca, N., Cicolella. A., Bates, M. and Bastin, E. (1999). Pilot study of personal indoor and outdoor exposure to benzene, formaldehyde and acetaldehyde. *Environmental Science and Pollution Research* 6, 95-102.

Meininghaus, R. *et al.* (2001). Indoor and outdoor aldehyde concentrations in a medium-sized French town. In: Latini, G. and Brebbia, C.A. (eds), *Air Pollution IX*, pp. 263-271. Southampton, Boston: WIT Press.

Meininghaus, R., Bastin, E., Gonzalez-Flesca, N. and Cicolella, A. (2002). A weighted sum parameter to simplify discussion on aldehyde exposure. *Conf. Proc. Indoor Air 2002, 9th International Conference on Indoor Air Quality and Climate*, Monterey, USA, Vol. 2, pp 619-624.

Meininghaus, R., Kouniali, A., Mandin, C. and Cicolella, A. (2003). Risk assessment of sensory irritants in indoor air—a case study in a French school. *Environment International* 28, 553-557.

Nielsen, G.D., Hansen, L.F., Nexoe, B.A. and Poulsen, O.M. (1996). Toxicological based air quality guidelines for substances in indoor air. Nordic Committee on Building Regulations, NKB, Indoor Climate Committee.

Smedje, G. and Norbâck, D. (2001). Irritants and allergens at school in relation to furnishing and cleaning. *Indoor Air* **11**, 127–133.

Ten Brinke, J.S. *et al* (1998). Development of a new volatile organic compound (VOC) exposure metrics and their relationship to "sick building syndrome". *Indoor Air* 8, 140-152.

Ulrich, D., Gleue, C., Weiland, S. and Seifert, B. (1999). Indoor air concentrations of aldehydes—a field study using DNPH diffusive sampling. *Proceedings of Indoor Air '99*, Vol. 4, pp. 89-94.

US-EPA (February 2003). Indoor air quality and student performance, Draft Revision to the August 2000 Fact Sheet EPA-402-F-00-009.

WHO (2000). *Air Quality Guidelines for Europe*, 2nd edn., *European Series, N°91*. Copenhagen: WHO Regional Office for Europe, WHO Regional Publications.