



HAL
open science

Human exposure to semi-volatile organic compounds (SVOCs) via dust ingestion: a review of influencing factors

Gaëlle Raffy, Fabien Mercier, Philippe Glorennec, Corinne Mandin, Barbara Le Bot

► To cite this version:

Gaëlle Raffy, Fabien Mercier, Philippe Glorennec, Corinne Mandin, Barbara Le Bot. Human exposure to semi-volatile organic compounds (SVOCs) via dust ingestion: a review of influencing factors. The 14th International Conference on Indoor Air Quality and Climate "Indoor Air 2016", International Society of Indoor Air Quality and Climate, Jul 2016, Ghent, Belgium. hal-01690117

HAL Id: hal-01690117

<https://ehesp.hal.science/hal-01690117v1>

Submitted on 26 May 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Human exposure to semi-volatile organic compounds (SVOCs) via dust ingestion: a review of influencing factors

Gaëlle Raffy^{1,2,3*}, Fabien Mercier^{1,2,3}, Philippe Glorennec^{1,2}, Corinne Mandin⁴, Barbara Le Bot^{1,2,3}

¹ EHESP - School of public health Sorbonne Paris Cité, Rennes, France

² Irset-Inserm UMR 1085- Research Institute for Environmental and Occupational Health, Rennes, France

³ LERES - Environment and health research laboratory, Rennes, France

⁴ Université Paris Est, CSTB - Scientific and technical center for building, OQAI - French indoor air quality observatory, Marne-la-Vallée, France

* gaille.raffy@ehesp.fr

SUMMARY

Dust ingestion is a non-negligible pathway of human exposure to several SVOCs. To get a better knowledge on this human exposure, a review of the literature was performed on its influencing factors including (1) the fraction of dust that enters the body via hand to mouth contact: dust with particle size < 100 µm was deemed more relevant to human exposure, and (2) the fraction of pollutant released in the digestive tract, i.e. the bioaccessibility of SVOCs: the composition of the matrix, the dust particle size, the physicochemical characteristics of the pollutant, the way the SVOC has contaminated dust, i.e. through adsorption or material abrasion, and the use of Tenax as a sink were among the main determinants.

PRACTICAL IMPLICATIONS

Taking bioaccessibility into account allows a better estimation of the exposure dose via dust ingestion and thus a more accurate human risk assessment. In vitro studies are proxies of bioavailability data and are easier to implement particularly from an ethical point of view.

KEYWORDS

Bioaccessibility, dust particle size

INTRODUCTION

Humans are exposed to a wide range of indoor chemical pollutants including SVOCs, which are suspected of adverse health effects such as reprotoxic and neurotoxic effects (Fournier et al., 2014). Dust ingestion is a non-negligible pathway of human exposure to several SVOCs (Bekö et al., 2015; Tue et al., 2013). To improve this human exposure assessment, it is necessary to consider the fraction of dust that will enter the body via hand to mouth contact and the quantity of pollutants released in the digestive tract. The present work reviews the literature related to the size of ingested dust particles and the bioaccessibility of indoor SVOCs.

DUST PARTICLE SIZE

The size of ingested dust particle is very important, particularly because SVOC concentrations vary significantly with particle size. First, in general, concentration of toxic chemicals in dust increases as particle size decreases (Lewis et al., 1999). Second, studies show that fine particles adhere better to human's hands than larger ones (Cao et al., 2012). The size of dust particles adherent to hands was measured and a particle size distribution of 29 ± 22 µm was

reported (Cao et al., 2013). Furthermore if $< 150 \mu\text{m}$ was considered as skin adherent dust fraction, 86% of this fraction would be in a 9.3-105 μm range (Kefeni and Okonkwo, 2014).

SVOC BIOACCESSIBILITY IN DUST

Regarding bioaccessibility, most reported methods simulated the gastrointestinal tract, dust being successively submitted to synthetic gastric and intestinal fluid (Yu et al., 2011). The model was sometimes extended to saliva (Ertl and Butte, 2012) or colon (Abdallah et al., 2012) digestion. The presence of food could be considered with the addition of milk powder (Ertl and Butte, 2012). Tenax beads were also used as an adsorption sink to estimate the dynamic absorption of SVOCs (Fang and Stapleton, 2014).

SVOC bioaccessibility is influenced by several factors related to the matrix: the organic carbon content was often associated with a decrease of bioaccessibility, for example for polybrominated diphenyl ethers (PBDEs) (Yu et al., 2012, 2013) or the more hydrophobic organophosphorous flame retardants and phthalate esters, but no effect was noticed on the less hydrophobic ones (He et al., 2015). A decrease of dust particle size (Wang et al., 2013c; Wang et al., 2013b) or an increase of dust pore volumes (Yu et al., 2013) lead to a larger specific surface area which was linked to an increase of SVOC bioaccessibility. Dust aging was tested for flame retardants and showed a decrease of their bioaccessibility for older dust samples (Fang and Stapleton, 2014).

SVOC bioaccessibility was also influenced by factors related to the compound itself. For example, substances with higher octanol-water partition coefficients (K_{ow}) were less bioaccessible (Kang et al., 2012, 2013; Wang et al., 2013a). For PBDEs, congeners that had integrated dust by adsorption were more bioaccessible than BDE 209 whose presence in dust is suspected to originate from material abrasion (Yu et al., 2013), although this origin could not be confirmed (Abdallah et al., 2012). SVOC bioaccessibility was not influenced by the pollutant's concentration (Yu et al., 2011).

Last, SVOC bioaccessibility was positively influenced by parameters of the method itself such as the use of Tenax (Fang and Stapleton, 2014) or milk powder (Ertl and Butte, 2012) and the increase of the concentration of bile in the intestinal solution (He et al., 2015). This emphasizes the need of a physiologically relevant, standardized measurement protocol (Collins et al., 2015).

Overall, measured bioaccessibilities were subject to a large variability, ranging from $< 20\%$ for BDE 209 (Yu et al., 2013), polycyclic aromatic hydrocarbons (Kang et al., 2011) or high molecular weight phthalates (Wang et al., 2013d), up to $> 60\%$ for OPFRs, low molecular weight PBDEs (Fang and Stapleton, 2014) or tetrabromobisphenol A and hexabromocyclodecanes (Abdallah et al., 2012). This confirms that taking bioaccessibility into account allows a better estimation of the ingested dose, whereas the latter could be overestimated when the studied pollutants are considered 100% bioaccessible.

CONCLUSIONS

Bioaccessibility data are useful for a better quantification of SVOC exposure doses and thus for a better estimation of associated health risks. However more studies are needed to assess SVOC bioaccessibilities, which should be compared to in-vivo studies for validation.

REFERENCES

Abdallah, M.A.-E., Tilston, E., Harrad, S. and Collins, C. (2012) In vitro assessment of the

- bioaccessibility of brominated flame retardants in indoor dust using a colon extended model of the human gastrointestinal tract, *J. Environ. Monit.*, **14**, 3276–3283.
- Bekö, G., Callesen, M., Weschler, C.J., Toftum, J., Langer, S., Sigsgaard, T., Høst, A., Kold Jensen, T. and Clausen, G. (2015) Phthalate exposure through different pathways and allergic sensitization in preschool children with asthma, allergic rhinoconjunctivitis and atopic dermatitis, *Environ. Res.*, **137**, 432–439.
- Cao, Z., Yu, G., Chen, Y., Liu, C., Liu, K., Zhang, T., Wang, B., Deng, S. and Huang, J. (2013) Mechanisms influencing the BFR distribution patterns in office dust and implications for estimating human exposure, *J. Hazard. Mater.*, **252-253**, 11–18.
- Cao, Z.-G., Yu, G., Chen, Y.-S., Cao, Q.-M., Fiedler, H., Deng, S.-B., Huang, J. and Wang, B. (2012) Particle size: a missing factor in risk assessment of human exposure to toxic chemicals in settled indoor dust, *Environ. Int.*, **49**, 24–30.
- Collins, C.D., Craggs, M., Garcia-Alcega, S., Kademoglou, K. and Lowe, S. (2015) ‘Towards a unified approach for the determination of the bioaccessibility of organic pollutants’, *Environ. Int.*, **78**, 24–31.
- Ertl, H. and Butte, W. (2012) Bioaccessibility of pesticides and polychlorinated biphenyls from house dust: in-vitro methods and human exposure assessment, *J. Expo. Sci. Environ. Epidemiol.*, 1–10.
- Fang, M. and Stapleton, H.M. (2014) Evaluating the bioaccessibility of flame retardants in house dust using an in vitro Tenax bead-assisted sorptive physiologically based method, *Environ. Sci. Technol.*, **48**, 13323–13330.
- Fournier, K., Glorennec, P. and Bonvallot, N. (2014) An exposure-based framework for grouping pollutants for a cumulative risk assessment approach: case study of indoor semi-volatile organic compounds, *Environ. Res.*, **130**, 20–28.
- He, R., Li, Y., Xiang, P., Li, C., Zhou, C., Zhang, S., Cui, X. and Ma, L.Q. (2015) Organophosphorus flame retardants and phthalate esters in indoor dust from different microenvironments: Bioaccessibility and risk assessment, *Chemosphere*, **2010**, 1–8.
- Kang, Y., Cheung, K.C. and Wong, M.H. (2011) Mutagenicity, genotoxicity and carcinogenic risk assessment of indoor dust from three major cities around the Pearl River Delta, *Environ. Int.*, **37**, 637–643.
- Kang, Y., Man, Y.B., Cheung, K.C. and Wong, M.H. (2012) Risk Assessment of Human Exposure to Bioaccessible Phthalate Esters via Indoor Dust around the Pearl River Delta, *Environ. Sci. Technol.*, **46**, 8422–8430.
- Kang, Y., Yin, Y., Man, Y., Li, L., Zhang, Q., Zeng, L. and Luo, J. (2013) Bioaccessibility of polychlorinated biphenyls in workplace dust and its implication for risk assessment, *Chemosphere*, **93**, 924–930.
- Kefeni, K.K. and Okonkwo, J.O. (2014) Distribution of polybrominated diphenyl ethers and dust particle size fractions adherent to skin in indoor dust, Pretoria, South Africa, *Environ. Sci. Pollut. Res.*, **21**, 4376–4386.
- Lewis, R.G., Fortune, C.R., Willis, R.D., Camann, D.E. and Antley, J.T. (1999) Distribution of pesticides and polycyclic aromatic hydrocarbons in house dust as a function of particle size, *Environ. Health Perspect.*, **107**, 721–726.
- Tue, N.M., Takahashi, S., Suzuki, G., Isobe, T., Viet, P.H., Kobara, Y., Seike, N., Zhang, G., Sudaryanto, A. and Tanabe, S. (2013) Contamination of indoor dust and air by polychlorinated biphenyls and brominated flame retardants and relevance of non-dietary exposure in Vietnamese informal e-waste recycling sites, *Environ. Int.*, **51**, 160–167.
- Wang, W., Huang, M.-J., Zheng, J.-S., Cheung, K.C. and Wong, M.H. (2013) Exposure assessment and distribution of polychlorinated biphenyls (PCBs) contained in indoor and outdoor dusts and the impacts of particle size and bioaccessibility., *Sci. Total Environ.*, **463-464**, 1201–1209.

- Wang, W., Huang, M., Wu, F., Kang, Y., Wang, H.-S., Cheung, K.C. and Wong, M.H. (2013) Risk assessment of bioaccessible organochlorine pesticides exposure via indoor and outdoor dust, *Atmos. Environ.*, **77**, 525–533.
- Wang, W., Wu, F., Zheng, J. and Wong, M.H. (2013) Risk assessments of PAHs and Hg exposure via settled house dust and street dust, linking with their correlations in human hair, *J. Hazard. Mater.*, **263**, 627–637.
- Wang, W., Wu, F., Huang, M. and Kang, Y. (2013) Size fraction effect on phthalate esters accumulation, bioaccessibility and in vitro cytotoxicity of indoor / outdoor dust, and risk assessment of human exposure, *J. Hazard. Mater.*, **261**, 753–762.
- Yu, Y., Pang, Y., Zhang, X., Li, C., Yu, Z. and Fu, J. (2011) Optimization of an in vitro method to measure the bioaccessibility of polybrominated diphenyl ethers in dust using response surface methodology, *J. Environ. Sci.*, **23**, 1738–1746.
- Yu, Y., Pang, Y., Li, C., Li, J., Zhang, X., Yu, Z., Feng, J., Wu, M., Sheng, G. and Fu, J. (2012) Concentrations and seasonal variations of polybrominated diphenyl ethers (PBDEs) in in- and out-house dust and human daily intake via dust ingestion corrected with bioaccessibility of PBDEs, *Environ. Int.*, **42**, 124–131.
- Yu, Y., Yang, D., Wang, X., Huang, N., Zhang, X., Zhang, D. and Fu, J. (2013) Factors influencing on the bioaccessibility of polybrominated diphenyl ethers in size-specific dust from air conditioner filters, *Chemosphere*, **93**, 2603–2611.