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5 Authors express here their personal point of view, without institutional and/or agency endorsement.
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9 **Abstract**

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11 Indoor settled dust may result in substantial human exposure to chemicals, especially by ingestion
12 following hand-to-mouth or hand-to-object-to-mouth contact. As with other environmental media
13 related to exposure, dust may thus be subject to regulation. An international scientific workshop was
14 convened in Paris in September 2019 to assess the relevance for public health of setting guidelines for
15 indoor settled dust, and secondly to discuss scientific and technical challenges related to such
16 guidelines. The main discussions and conclusions, with consensus achieved, are reported herein.
17 Discussions concerned general considerations, objectives and definitions, relevance for a health-based
18 guideline, units of measure, and finally derivation of the guideline. These points should be addressed
19 when considering an indoor settled dust guideline as part of a policy to reduce exposure indoors to a
20 given chemical or group of chemicals.
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25 **Practical Implications**

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27 Indoor settled dust may result in substantial human exposure to chemicals. An international scientific
28 workshop was convened in Paris in September 2019 to assess the relevance for public health of setting
29 guidelines for indoor settled dust, and to discuss related scientific and technical challenges. An indoor
30 settled dust guideline can inform future policy to help reduce indoor exposure to chemicals.
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33 **Keywords**

34 Environmental health, exposure, indoor air quality, indoor environment, chemical safety,
35 environmental policy.
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Introduction

Indoor settled dust may result in direct human exposure to chemicals by ingestion following hand-to-mouth or hand-to-object-to-mouth contact, inhalation of re-suspended particles, or dermal penetration by contact. This exposure can be evidenced by the existence of a correlation between the concentration of a compound in dust and its concentration (or concentration of a metabolite) in relevant human tissues or body fluids. For lead, the contribution of ingested settled dust to total exposure is well documented by numerous studies with consistent results. Lanphear et al. (1998) in the United States, Levallois et al. (2014) in Quebec, Canada, and Etchevers et al. (2015) in France have demonstrated a significant correlation between the lead concentration of sampled floor dust and the blood lead levels of children. A recent review of studies conducted since 2005 on chemicals in dust deposited in indoor environments in Europe, North America, Australia and New Zealand suggested dust by ingestion can be a relevant source of exposure for a variety of chemicals (Larsson and Berglund, 2018). In particular, the authors showed dust ingestion can be a strong contributor to total dust exposure for brominated flame retardants, certain phthalates and polycyclic aromatic hydrocarbons (PAHs).

Controlling environmental exposure is one of the ways to reduce potential damage to human health. Guidelines exist for outdoor air and indoor air, water, food, consumer products, building materials, and sometimes soils, but not for dust with the exception of lead: in 2019, U.S. EPA lowered the dust-lead hazard standards for floors to $108 \mu\text{g}/\text{m}^2$ ($10 \mu\text{g}/\text{ft}^2$) to protect children from the harmful effects of lead exposure (USEPA 2019).

In France, the agency for food, environmental and occupational health safety (Anses) studies the feasibility and relevance of setting guidelines for chemicals present in indoor settled dust in dwellings and public places as schools, for instance. Anses proposed to discuss and address the associated challenges such as multi-pathway and multi-route exposure within the scientific community. Anses created a dedicated working group in 2018 and, in the absence of literature on indoor settled dust guidelines, a dedicated scientific international workshop was convened in September 2019 in Paris. The objectives were firstly to assess the relevance for public health of setting guidelines for indoor settled dust (Indoor Settled Dust Guideline, or ISDG), and secondly to discuss scientific and technical challenges related to such guidelines. The main discussions and conclusions, with consensus achieved, are reported.

General considerations

Before setting an ISDG, its public health benefit has to be evaluated. While this benefit may seem obvious for lead, the benefit would need to be assessed separately for other chemicals found in indoor settled dust.

The objective of an ISDG should *not* be to promote measurements of settled dust concentrations by individuals themselves.

Any guideline such as an ISDG should be accompanied by a measurement protocol, including both sampling and analytical aspects.

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3 Independently of a possible ISDG, a general public health risk communication message should
4 be to clean and remove dust on surfaces, especially when accessible to children, as often as
5 possible.
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8 **Key points**

9 **Objectives and proposal for corresponding definitions**

10 A human health based guideline like an ISDG helps to answer the question “*is there a risk?*” It
11 could be a “concern” or “alert” value, depending on the level of risk corresponding to the
12 guideline. A “concern” ISDG may correspond to dose via ingested dust equal to or higher than
13 a fraction of tolerable daily intake (e.g. 20% for non-carcinogenic endpoints), while an “alert”
14 ISDG may correspond to an ingested dust equal to or higher than the tolerable daily intake.
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18 Another complementary environment-based value may be useful to answer the question: “is
19 there contamination?” Such a comparison value would be based on typical values of the
20 environmental distribution, e.g. 95th percentile of observed values in national or regional
21 indoor settled dust surveys. This approach is oriented towards source reduction, different
22 environments (schools, dwellings, etc.) have to be considered.
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25 **Relevance criteria for a health based guideline**

26 An ISDG may be relevant for chronic environmental exposures in cases where dust accounts
27 for a “**certain part**” of **total exposure** for the majority of the target population, *or*, for the most
28 exposed people. Given the inherent uncertainty, the group thought this “certain part” must be
29 substantial, perhaps situated around 30-50% of total exposure for the majority or the most
30 exposed people. The discussion of relevance should therefore also consider the possible
31 existence of other exposure sources (diet, consumer products...).

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33 In addition, the relevance of an ISDG depends also on the availability of a **toxicological**
34 **reference value** (oral chronic reference dose or tolerable daily intake for instance).
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38 A **priority ranking of target compounds** is necessary, without excluding banned compounds
39 because of their possible long persistence in the environment.
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42 **Cumulative risks** need to be considered, e.g., phthalates instead of as diethyl hexyl phthalate,
43 notably because of continuous substitution of an individual chemical or congener in a category.
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46 **Measurement Units for ISDG**

47 Two expressions of measurement units, surface area concentration (or loading) and mass
48 concentration (or concentration), both have their own strengths and limitations, and are thus
49 complementary.
50

51 **Loading ($\mu\text{g}/\text{m}^2$)** was judged by the group to be a better indicator of exposure because it
52 combines the dustiness of the indoor environment and the concentration of the compound in
53 dust (Rasmussen et al., 2017). Studies with lead have suggested dust loading correlates better
54 with children's blood levels than does the concentration (Davies et al, 1990; Lanphear et al,
55 1995). Its measurement could be achieved with a wipe or with a specific vacuum cleaner
56 (Mercier et al., 2011; Kubwabo et al., 2013; Rasmussen et al., 2017), on a measured surface
57 area. One limitation is the spot measurement of loading is influenced by the delay between
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3 last cleaning and sampling. Another limitation is the assessment of calculated dose needs an
4 empirically derived -transfer coefficient, expressed in m^2/day , to aggregate the mass transfer
5 associated with a series of contacts. An alternative is to use a default dustiness assumption in
6 mg/m^2 and a default dust intake rate in mg/day (or a conservative intake rate for a protective
7 health-based value). Both transfer coefficient and default dustiness assumptions have large
8 uncertainties (Cohen Hubal et al., 2006; Wilson et al., 2016).
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11 **Concentration ($\mu\text{g}/\text{g}$)** more clearly identifies presence of sources, and is less influenced by the
12 delay since the last cleaning. A strength is this value could be obtained from the analysis of
13 dust easily collected in the bag of a vacuum cleaner (household or specific) (Kubwabo et al.,
14 2013; Rasmussen et al., 2017). Estimates of intake and dose, however, still necessitate the use
15 of a default, age-specific dust intake rate in mg/day (U.S. Environmental Protection Agency.
16 Exposure Factors Handbook).
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20 In addition, the selection of a sampling protocol (e.g. surface wipe versus vacuum) may be
21 driven by the risk assessment approach to be used, but also by the need to collect adequate
22 dust mass for analysis as well as to avoid inadvertent contamination of the dust sample.
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25 Deriving an ISDG

26 Because both exposure and susceptibility (and vulnerability to adverse health outcomes) vary
27 over the course of an individual's lifetime, different **age groups** have to be considered during
28 the guideline derivation process, even if at the end a unique value, the lowest one, is proposed.
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31 In the absence of complete data, use of an arbitrary proportional **contribution of ingested dust**
32 to total exposure is recommended, because it is easier to calculate (less data needed), easier
33 to communicate and allows consistency of the approach between media (e.g. drinking water
34 guidelines). A default contribution of 20% such as is recommended in the WHO drinking water
35 quality guidelines (World Health Organization 2011) or in the Canadian protocol for setting soil
36 quality guidelines (Canadian Council of Ministers of the Environment, 2006) is suggested,
37 which may be further modified if data make it possible and more useful. An alternative
38 approach, but not recommended, is to determine contribution of ingested dust by allocating
39 rates of intake from other pathways and routes of exposures to the toxicological reference
40 value; however, this approach requires more data, especially recent representative data, and
41 the confidence that every source of exposure has been identified.
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46 Concerning the oral **bioaccessibility** of chemicals in dust, a default value of 100% is
47 recommended, which could be replaced with a defensible lower value if robust data are
48 available. Indeed, there are no *in vivo* validated tests for organics, and therefore few data,
49 whereas there is a large variability between chemicals and among places (Raffy et al. 2018).
50 Considering a pathway specific bioaccessibility adjustment would ideally require, to ensure
51 consistency, also considering such a correction for other exposure pathways and routes, which
52 may be difficult in practice due to lack of data.
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Conclusion

The workshop participants reached a consensus that an indoor settled dust guideline, or ISDG, may add value to and be an integral component in support of a general policy to reduce exposure to a given chemical or group of chemicals.

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Conflicts of interest:

The authors declare they do not have any financial conflict of interest associated with the question of setting of public health guidelines for indoor settled dust.

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