Exposure to Air Pollutants Indoor

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Mini Review

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ABSTRACT

Over decades, the attention of atmospheric scientists and air quality managers focused on the quality of outdoor air and its impact on human health. Nonetheless, human exposure to air pollutants occurs mainly in indoor environments because people spend much of their time (on average 85% to 90%) in confined spaces (homes, office buildings, schools etc.). They are exposed to a complex mixture of air contaminants at concentrations often several times higher than outdoors. On average, we inhale between 14–20 cubic meters of air daily, *i.e.,* ca.15–18 kg of air per day, 80%–90% indoors. In comparison: adults consume 2 to 3 liters of liquids and 1 to 2 kilograms of food per day. The comparison between inhalation and ingestion is an approximation because the contact time of air/liquid/food with the body is different. So, the risk of exposure by inhalation or ingestion cannot be as fully equivalent. Because of the COVID-19 pandemic, people have changed their daily life behaviors and activities; they have to stay and work more at home, exposed to indoor air contaminants for extended periods.

INTRODUCTION

Air pollutants e.g. benzene, formaldehyde, CO, CO_2, NOx have many potential sources inside residential (homes) and work places (office buildings, schools). Given the time most people spend indoors, human exposure to air pollutants is governed to a great extent by the presence of the compounds in indoor environments, rather than by their presence in ambient air. The current European Union (EU) policy and plans on urban air quality include that citizens are to be effectively protected from risks to health from air pollutants. EU legislation addresses, among others, air quality standards, national emission ceilings and emissions from vehicles and industries [1]. The European commission through its environment and health strategy and action plan and, more recently, its health and consumer protection strategy and the world health organization significantly contributed to understanding of the impact of poor indoor air quality on human health and wellbeing, individuate pollutants with a potential risk for health and promote initiatives to reducing or eliminating air pollution indoors [2-4].

Exposure of humans to outdoor and indoor air pollutants has led to the concept of total human exposure and the herewith associated human health risk.

In the first half of the 2000's emerged the necessity to identify and establish priorities for indoor air pollutants, based on their sources and concentrations in indoor environments that may pose a potential risk for health for the exposed individuals [5].

Accumulation of indoor air contaminants

- Open windows permitting the penetration of outdoor air pollutants into indoor environments,
- Activities of the occupants (cleaning, smoking), which lead to the emission of some very specific individual compounds and/or mixtures of compounds belonging to various chemical classes,
- Emissions from building or construction materials used indoors,
- Construction of air tight buildings to reduce energy consumption changes in ventilation regimes applied in buildings

LITERATURE REVIEW

Prioritization of volatile organic compounds for indoor air quality (EU, WHO)

The European Union (EU) approach: The EU-INDEX project (critical appraisal of the setting and implementation of indoor exposure limits in the EU) started in 2002 and concluded in 2005. It was a breakthrough in indoor air quality [6]. It was the first attempt to identify and establish priorities of air pollutants in indoor environments that may pose a potential risk for health for exposed individuals [7-10]. The European commission's directorate general for health and consumer protection (DG SANCO, now DG health and food safety) financially supported the project that was co ordinated and carried out by the European commission's joint research center (JRC-Ispra, Italy) in collaboration with leading European experts in the area of indoor air pollution and human exposure. The scope of INDEX was to:

- Identify priorities of indoor air pollutants based on their health risks.
- Give recommendations to manage those risks and
- Assess the need of a community strategy for indoor air pollution.

Based on the conclusions of the assessment and completeness of individual databases, within the frame of the INDEX project a priority ranking was arranged with 14 out of 41 chemicals assigned to three groups as follows:
Group 1: High priority pollutants.
Formaldehyde, benzene, carbon monoxide, nitrogen dioxide and naphthalene.
Group 2: Second priority pollutants.
Acetaldehyde, toluene, xylenes and styrene.
Group 3: Chemicals requiring further research (with regard to human exposure or dose response).
Ammonia, limonene and a-pinene.

RESULTS AND DISCUSSION

The World Health Organization (WHO) approach development of guidelines for indoor air quality selected compounds.

WHO concluded and published in 2010, after a thorough consultation by an expert group, the development of Indoor air quality guidelines for selected pollutants. The compounds included in the WHO Indoor Air Quality (IAQ) guidelines are benzene, carbon monoxide, formaldehyde, naphthalene, nitrogen dioxide, polycyclic aromatic hydrocarbons (especially benzo-a-pyrene), trichloroethylene, tetrachloroethylene and radon.
According to the WHO expert group, the selected chemicals have indoor sources, are known as hazardous to human health and are often found in indoor environments in concentrations of health concern. WHO -IAQ guidelines are targeted at public health professionals and authori ties involved in the design and use of buildings, indoor materials and products. They provide a scientific basis for le gally enforceable standards (Table 1).

Table 1. (A) Indoor exposure limits the EU-INDEX project (critical appraisal of the setting and implementation of indoor exposure limits in the EU); (B) WHO guidelines for indoor air pollutants.

(A)	(B)
Formaldehyde (HCHO)	**Formaldehyde (HCHO)**
30 μg/m³ as 30 min average	0.1 mg/m³ as 30 min average
Benzene	**Benzene**
As benzene is a human carcinogen, its concentration in the air should be as low as reasonably achievable. Indoor	No safe level of exposure can be recommended Unit risk of leukemia per 1 μg/m³ air concentration is 6×10^{-6}.The concentrations of airborne benzene associated with an excess lifetime

air concentrations of benzene should not exceed outdoor concentrations.	risk of 1/10 000, 1/100 000 and 1/1 000 000 are 17, 1.7 and 0.17 µg/m^3, respectively.
CO	**CO**
The 1 h average guideline value of 30 mg/m_3 and the 8 h average guideline value of 10 mg/m^3 are recommended.	100 mg/m^3-15 minutes 35 mg/m^3-1 hour 10 mg/m^3-8 hours 7 mg/m^3-24 hours
NO_2	**NO_2**
A long term guideline value of 40 µg/m^3 (1 week average), and a short term guideline value of 200 µg/m^3 are proposed.	200 µg/m^3 1 hour average, 40 µg/m^3 annual average
Naphthalene	**Naphthalene**
A long term guideline value of 10 µg/m^3 is recommended based irritation/inflammation/hyperplasia. This level is at the lower extreme of the olfactory perception range.	0.01 mg/m^3 annual average
Outdoor benzene reference value: 5 µg/m^3, annual mean.	**PAHs**
	No threshold can be determined, and all indoor exposures are considered relevant to health. Unit risk for lung cancer of PAH mixtures is estimated to be 8.7 x 10^{-5} per ng/m^3 of B(a)P The corresponding concentrations for lifetime exposure to B(a)P producing excess lifetime cancer risks of 1/10 000, 1/100 000 and 1/1 000 000 are approximately 1.2, 0.12 and 0.012 ng/m^3, respectively.
	Trichloroethylene
	Unit risk estimate of 4.3 x 10^{-7} per µg/m^3 The concentrations of airborne trichloroethylene associated with an excess lifetime cancer risk of 1/10 000, 1/100 000 and 1/1 000 000 are 230, 23 and 2.3 µg/m^3, respectively
	Tetrachloroethylene
	0.25 mg/m^3 annual average
	Radon
	WHO guidelines provide a comprehensive approach to the management of health risk related to radon

CONCLUSION

The analysis of the existing data on indoor/outdoor air concentrations and exposure estimates for benzene and formaldehyde in European cities shows, that indoor air concentration levels and the time spent indoors clearly determine human air exposure. However, there is a need to harmonize measuring protocols and techniques and the assessment of personal exposure to air pollutants. This assessment requires a broad consensus on harmonized methodological approaches for sampling and analytical measurement techniques and exposure estimates for a reliable evaluation of human health risk. As a very positive step to improve the indoor air quality in buildings/schools and ameliorate occupant's wellbeing and comfort could be introducing the Indoor Air Quality (IAQ) certificate of buildings in analogy to energy performance certificate proposed by the European Union (EU) and implemented in the majority of the member states. The IAQ certificate for buildings would motivate and stimulate architects and engineers to use the appropriate products for new and the renovation of old buildings, for the wellbeing of the residents and at the same time for maintaining the value of the buildings.

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