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9th IWA Odour & VOC/Air Emission Conference
26-27 October 2021 Bilbao, Spain

PAPER

Occupational Exposure Of Olfactometric Examiners: Possible Solutions For The Risk Assessment

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Keywords: odorous emissions, dynamic olfactometry, odour analysis, occupational risk assessment; risk assessment

Abstract

The aim of this paper is the definition of a new method for the evaluation of occupational exposure risk for workers involved in dynamic olfactometry. These workers, also called panellists, can be exposed to hazardous pollutants potentially present in odourous mixtures. Despite the relevance of this topic, in the regulation and the scientific literature, a standardized method to evaluate the panellists' occupational is not provided. Therefore, this article aims to provide practical solutions for the risk assessment of olfactometric workers. The presented approach is based on the quantification of non-carcinogenic and carcinogenic risk for panellists' exposure, based on the evaluation of hazard index (HI) and the inhalation risk (IR) for the odorous mixtures. In addition, this approach aims to resolve the critical aspects observed in the literature models available during their application to real odorous samples. In particular, the absence of a clear definition of occupational exposure concentration and the presence of compounds without a toxicological threshold in the sample represents a problem of available the assessment models. Therefore, this study proposes a selection of the most appropriate reference values for the pollutants present in a real odorous sample. This implementation allows to calculate, in a robust manner, the minimum dilution value to be adopted during the analysis of odorous.

1. Introduction

Odorous emission represents an important pollutant to be controlled and monitored (Nicell, 2009). The emission of odorous compounds is a relevant problem for different types of industries due to their negative environmental and health effects. Due to these potential consequences, in particular on human health, odour emission often causes a multitude of complaints from the population to local authorities (Bokowa et al., 2021; Henshaw et al., 2006). Because of these complaints and concerns, the monitoring of

odorous emissions from an industrial plant are increasingly required by the control agencies. In order to quantify odorous emissions, one of the most diffuse techniques is dynamic olfactometry. By dynamic olfactometry, indeed, it is possible to quantify odour concentration, expressed in odour units per cubic meter (ou_E/m^3). At the European level, this technique is standardised by EN 13725:2003 and leverages the ability of the human nose to be stimulated by an odorant. As a result, dynamic olfactometry involves directly human examiners, also called *panellists*, to determine odour concentration. Sample odour concentration is defined as the number of dilutions required for the sample to reach the odour threshold level. Indeed, during the analysis, the sample is presented to the human assessors at increasing concentrations by an *olfactometer*, a specific equipment that dilutes odour samples according to defined ratios with neutral air (Bax et al., 2020). Therefore, during olfactometric measurements, panellists are directly exposed, at increasing concentration, to odour. However, odorous samples can potentially contain compounds hazardous to human health: by this, panellists are exposed to an undefined occupational risk during their working activity. To perform an olfactometric analysis in safety conditions, it is fundamental to evaluate the exposure risk for panellists involved and guarantee their health. The only valuable protection measure to protect assessors' health is the definition of the minimum dilution value to be not exceeded during the sample analysis. Indeed, the common protection systems used in working environments cannot be applied in this particular case due to the strict limitations that exist according to the particular exposure of panellists and to the regulation on sample management. Indeed, EN 13725 doesn't permit the removal of hazardous pollutants in order to avoid samples' alteration. In addition, personal protective equipment (i.e. respiratory protective equipment) cannot be adopted not to compromise the conduct of olfactometric analysis. Therefore, the definition of the minimum dilution value to be adopted is fundamental to guarantee assessors safety. To define the dilution level to be not exceeded, the estimation of the exposure risk for panellists involved in dynamic olfactometry is necessary (Polvara et al., 2021). The issue of exposure risk for examiners involved in dynamic olfactometry and the necessity of protecting their health is well known. Indeed, both EN 13725:2003 and the current revision of the standard (prEN 13725:2018) require consideration of the exposure risk related to the analyses for panellists involved. Indeed, EN 13725 prescribes to inform the employees involved of the potential exposure risk correlated with olfactometric analysis and it requires to minimise it and the current revision should introduce more detailed guidance on risk assessment for assessors, prescribing the use of the current occupational exposure limits. However, at the current state, the regulation provides general information and don't describe a standardized method for the estimation of panellists' exposure risk. In addition, the standard revision doesn't define the reference concentration to be adopted in the evaluation: this can lead to non-comparable and even incorrect assessment of the panellists' exposure risk. In the scientific literature, only two papers have proposed a methodology for the evaluation of occupational exposure risk for panellists involved in dynamic olfactometry and for the definition of a minimum dilution value (Davoli et al., 2012, 2016). Despite the importance of these studies in the occupational risk assessment of olfactometric examiners, the methodologies proposed present two main critical aspects. The first one is correlated with the application in the evaluation of different reference concentration. Indeed, the two studies applied different reference concentrations, in particular for non-carcinogenic effects, according to the particular database considered. In Davoli et al.,

2012 the TLV-STEL (Threshold Limit Value - Short Term Exposure Limit) value was applied as reference concentration. On the contrary, in Davoli et al., 2016 the Reference Concentration (RfC) was applied, weighted on the estimated panellist exposition. These two values are different for definition: indeed, TLV-STEL is specific for occupational exposure, whereas RfC refers to the exposition of the entire population (including sensitive subgroups). This variance can modify drastically the results obtained. For this reason, it is fundamental, at a regulatory level, to define a uniform source for the reference concentration to obtain comparable values. In addition, another critical point of the models proposed is the absence of a clear definition about the treatment in the toxicological evaluation of the compounds for which there is no exposure limit in the proposed databases. The presence of compounds for which no toxicological threshold is available can occur frequently in the case of real odorous samples. According to the method suggested, in particular for the calculation of non-carcinogenic effects based on the Hazard Index procedure, the absence of toxicological thresholds can influence the result obtained. Therefore, it is necessary to consider this issue in order to obtain a more appropriate and precise value of minimum dilution level to be not exceeded during the analysis of real odorous samples. Considering all these criticalities observed in the models available, there is a clear need to discuss an assessment method that considers these critical issues and that can be easily implemented and used to assess minimum dilution levels for real samples, in which compounds may be present for which an exposure threshold is not readily available. Therefore, this article aims to present a robust method for assessing occupational risk for panellists. The proposed method has been constructed to be easily usable by olfactometric operators and considering the criticalities observed in the literature models available.

2. Method description

Firstly, in order to conduct the toxicological evaluation for panellists and define the minimum dilution values to be adopted, it's necessary to conduct some preliminary consideration about their activity and define the panellists' exposure. Due to their role, olfactometric examiners have to be considered workers and therefore, as suggested in the standard revision, occupational exposure limits have to be adopted in the toxicological assessment. Nevertheless, panellists work for a limited time: indeed, the analysis session lasts 1 or 2 hours and the odour is presented for a maximum of 15 seconds for each dilution level. Therefore, the panellists' exposure can not be compared to the general workers one, based on a working activity of 8 hours per day and 40 hours per week. So, the selection of the reference concentration must consider this particular exposure into account. However, during their activities, examiners are exposed to gaseous mixtures collected directly at the odour source, following the sampling requirement of EN 13725:2003. Consequently, panellists can be potentially exposed to a relevant concentration of hazardous pollutants, theoretically equal to the source concentration. In addition, odorous samples can be generally classified as a discharge mixture which is typically complex and variable in composition. Therefore, with the increasing demand for this kind of sensorial analysis and the different nature of the sampled odour emissions and their potential hazard, it is necessary to introduce a robust, yet simple-to-use, method to estimate the occupational exposure risk for olfactometric panellists.

Then, the method here proposed was defined with the aim of characterising the health risk posed by the odour samples considering the critical aspects observed. As a function of the exposure modes, a non-carcinogenic risk assessment was calculated, based on short-term exposure, by the evaluation the *Hazard Index* (HI). Further, for carcinogenic health effects, an excess lifetime cancer risk was calculated considering a "non-threshold" toxicity and assuming a linear dose-response relationship.

2.1. Risk assessment: non-carcinogenic health effects

The potential non-carcinogenic chronic risk was evaluated using the *Hazard Index* (HI). The HI is equal to the sum of each chemical component's Hazard Quotient (HQ), as reported in Equation 1~~Equation 1~~. HQ for every pollutant is calculated to divide the exposure concentration (C_i exp) by the occupational limit value (OLV) considered, as shown in Equation 2~~Equation 2~~.

$$HI = \sum HQ_i \qquad \text{Equation 1}$$

$$HQ_i = C_i\,exp/OLV_i \qquad \text{Equation 2}$$

As described previously, being worker panels and following the description in the revision of the standard, an occupational limit should be used as a reference concentration.
Hazard Index represents a simple and flexible approach that can be quickly applied to different samples in the same scenario. The HI approach provides a clear index of acceptable risk: indeed, if HI ≤ 1, the risk is acceptable; if HI > 1, the risk is not acceptable. The principal drawback of HI method is that the reference values for all chemicals are required and often are not available. To resolve this critical aspect, in this study proposes different databases to select the appropriate reference value for the different chemicals that can be identified in odorous samples. In particular, this study proposes to use the Occupational Limit Values (OELs), defined by European Community, derived from the most recent scientific data available; the Derived No Effect Levels (DNELs) for workers' exposure and other occupational limit values, such as national limits or ACGIH (American Conference of Governmental Industrial Hygienists) Threshold Limit Values. The application of this procedure makes it possible to provide a toxicity value useful for calculating the HQ of a wide range of compounds present in a real odour sample. Applying this procedure, it is possible to characterize the HI of the entire mixture of chemicals and obtain its complete risk characterization. If the non-carcinogenic risk is higher than 1, a minimum dilution value must be set to guarantee panellists safety.

2.2. Risk assessment: carcinogenic health effects

Carcinogenic excess lifetime risk was calculated based on Equation 3~~Equation 3~~.

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$$\text{Inhalation Risk (IR)} = CDI_i \text{ X IUR} \qquad \text{Equation 3}$$

where CDI was the chronic daily intake, expressed in μg/m^3 and IUR is the Inhalation Unit Risk. IUR values were retrieved by the Risk Assessment Information System, while CDI has to be calculated in accordance with the working exposure time of the examiners involved in the olfactometric analysis (Equation 4~~Equation 4~~), applied the parameters specific to the individual laboratory and defined in Table 1.

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$$CDI_i = (C_i \text{ exp X EF X ED X ET}) / (AT \text{ X LT}) \quad \text{Equation 4}$$

Table 1: Parameters for evaluation of carcinogenic risk

Parameter	Abbreviation	Unit value
Exposure frequency	EF	Day/year
Exposure duration	ED	Year
Exposure time	ET	Hours/day
Averaging time	AT	Days/years
Lifetime	LT	Years

Therefore, to assess a realistic specific risk, it will be necessary for each olfactometric laboratory responsible to record in detail the representative work activity of the examiners involved. An acceptable carcinogenic risk level is defined for an IR lower than $< 10^{-5}$ in the case of mixtures, as in the case of odour samples.

3. Results and discussion

As previously described, during the analysis of odorous samples, examiners are exposed to increasing concentration of hazardous pollutant potentially present in the sample. Therefore, a minimum dilution level can be defined to avoid any health impact for the involved panellists. The minimum dilution level is defined as the dilution step not to be exceeded in order not to expose examiners to dangerous concentrations of pollutants. The determination of the minimum dilution value is defined on the results of the characterization of the non-cancerogenic risk (HI calculation) and of the carcinogenic risk (Inhalation Risk calculation). Indeed, by comparing the results obtained using the method proposed with the acceptable safety criteria for carcinogenic and non-carcinogenic risk, it is possible to define the minimum dilution level for an odour sample. If HI o IR are higher than the acceptable parameters, a minimum dilution value must be set to protect panellists' safety.

4. Conclusions

This work has aimed to propose some methodology solutions in order to assess the occupational exposure risk for panellists involved in dynamic olfactometry. The method proposed in this article is based on the assessment of carcinogenic and non-carcinogenic risks using values established by international regulations and commonly applied reference standards in the field of toxicology. The most important result of this study is the suggestion of different reference databases for the assessment of non-carcinogenic effects, based on the adequacy of available limits, to obtain toxicological information for the largest number of compounds present in a real odour sample.

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