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A New method to Evaluate Odour Annoyance Potential

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Nowadays olfactory discomfort is one of the most important factors of well-being. Different methods exist to calculate a discomfort indicator, but these indicators are based on one year human observations. However, only few methods are able to give information on concentration and acceptability of odours. These values are rarely combined to build an annoyance potential for odorous sources.
In this paper, a new method is proposed for the evaluation of odours acceptability. In this method the odour concentration determination (according to the EN 13725) is followed by odour acceptability determination. The measurement of acceptability is realised at different concentrations just above the threshold at which all panel members detect the odour. An extrapolation is done to obtain the acceptability of the sample at the real concentration. A potential of annoyance is calculated by multiplying odour concentration and acceptability.
In the last part of this paper, three examples are given to illustrate the interest of annoyance potential. Two deal with environmental odours (composting and rendering) to identify the most impacting sources. The third one concerns building materials.

1. Introduction

Environmental odours are an important subcategory of perceived air pollution, which, together with noise, heat and light, are discussed under the common heading of environmental stress. Environmental stressors perceived in residential areas, lead to increased insecurity feelings and negative perceptions of the quality of life (Evans and Cohen, 1987). Environmental odours are inherent parts of most industrial sites and may be the cause of an array of reactions, frequently becoming a cause of public environmental discomfort (Carmo, 2010). Odour annoyance has become a major environmental issue among neighborhood communities, local municipalities, state agencies and national governments around the world. Location of industries depends on their odour acceptability in the neighbourhood. Furthermore, sales of various products like for example building materials also depend very often on the odour annoyance they could generate.
Odour annoyance represents a very important issue of societal and industrial perspective. It is due to the intrinsic character of odour, frequency or moment of perception.
Currently, odorous impact evaluation is only based on odour persistence measurement, according to the EN 13725 standard. However, this determination is not sufficient to evaluate the odour annoyance. As a matter of fact, odour annoyance not only includes quantitative parameters like odour persistency or strength but also the acceptability (hedonic tone) of the odour. This last parameter, odour acceptability representing the pleasant or unpleasant character, is a key element in estimating odour annoyance (Van Harreveld, 2001). Several methods to evaluate the hedonic tone exist for example, VDI 3882-2 (1994), ISO NF 16000-28 (2012).
VDI 3882-2 proposes a method to evaluate the hedonic tone in environment to limit the impact of odour intensity, quality and toxicity by working at six different dilutions. NF 16000-28 described an evaluation of

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hedonic tone for odour emissions by materials but without any dilution of sample. In this case, quality and intensity of odour may affect the perception of the hedonic tone. Furthermore, panel is exposed to potentially toxic concentration. In both cases, evaluation needs about 15 members and the value is defined on a closed scale.

But the combination of odour concentration and hedonic tone to estimate odour annoyance is rarely used. At present, in the industrial odours prevention, concentration (odour persistence measure) and intensity are taken separately as parameters for assessing odorous impacts rather than acceptability. But these measurements do not reflect the real annoyance potential of an odour because odour annoyance is strongly influenced by hedonic tone (Sucker et al., 2008). This is the reason why a new proposition of annoyance potential indicator is proposed in this paper.

2. Acceptability evaluation

This new indicator requires two steps of analysis: determination of odour concentration followed by the evaluation of odour acceptability.
Odour concentration is obtained according to EN 13725.
Odour acceptability is evaluated using the method described below:

1. Determination of the dilution level which all members of the panel perceive odour.
2. Evaluation of odour acceptability at this level of dilution, on a closed scale ranging from -5 to +5 (-5 = very unpleasant odour, 0 = neutral odour, 5 = very pleasant odour).
3. Repetition of step 2 in three lower levels of dilution.
4. Calculation of the median acceptability level for each dilution.
5. Plotting of acceptability levels vs dilution levels.

The extrapolation of the regression line to no dilution provides the acceptability level for the test sample on an open scale ranging from - ∞ to + ∞.
As for VDI 3882-2, this method avoids exposing the panel members to high odour intensity levels, and potentially toxic concentrations.
This evaluation is realized using the same sample, olfactometer and panel (six members in our case) than those used for the determination of odour concentration.
The method has been tested with four molecules: anethole, limonene, butyric acid and DMDS, corresponding to pleasant (anethole – limonene) and unpleasant odours (butyric acid – DMDS).

For each compound, a minimum of three different analyses were realized on different days, with variable panel compositions and different sample concentrations (Table 1).

Table 1 : Odour concentration range, number of evaluations and number of panel for the determination of acceptability level

	Anethole	Limonene	Butyric acid	DMDS
Odour concentration range (ou_E/m^3)	167-9614	605-3046	833-48069	543-9504
Number of evaluations	3	10	3	3
Number of different panel	3	6	3	2

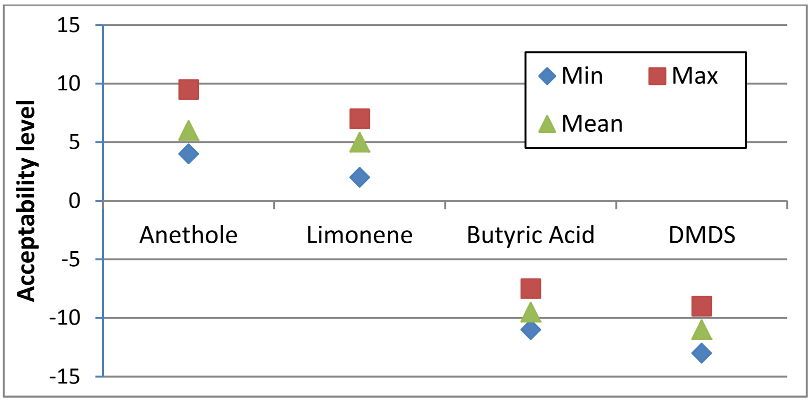

Figure 1: Acceptability levels of anethole, limonene, butyric acid and DMDS.

Figure 1 presents the results. So, an overview of reproducibility could be observed.
Acceptability levels of anethole and limonene are about +5 and those of butyric acid and DMDS about -10. Moreover, the relatively low levels of dispersion around the average value show that our method gives significant results. The two kinds of odours, pleasant and unpleasant, are clearly discriminated.

To conclude, the advantage of this method is that it allows to easily and quickly characterize both the odour concentration and the acceptability of an odorous sample, using a single sample and the same jury. By crossing the acceptability level with odour concentration, it is therefore possible to obtain an odour annoyance potential.

3. From acceptability to odour annoyance potential

In this part, three examples are presented to illustrate the interest of the annoyance potential. The first ones are based on samples coming from a composting plant and building materials, with similar odour concentrations. The third one concerns odours of different origins (composting and rendering plants) with different odour concentrations.

3.1 Samples from composting plants

In a composting plant, several odour sources can be identified: green wastes, sludges, fermentation, maturation and compost. Each source has a different impact on the neighborhood. To illustrate the importance of the acceptability evaluation, three different sources of odour with equal odour concentration (about 12,000 ou_E/m^3) have been considered (green wastes, compost and fermentation. After the determination of each odour concentration, the acceptability level is determined by the method described previously. The results are shown in Table 2

Table 2 : Odour concentrations and acceptability levels for green wastes, compost and fermentation

	Odour concentration (ou_E/m^3)	Acceptability level
Green Waste	12,047	+4.33
Compost	11,918	-5.36
Fermentation	13,418	-12.17

This table shows that two negative acceptability levels are obtained for compost odour (-6) and fermentation one (-12) whereas odour of green waste are perceived positively (+4).

Although our three samples have the same odour concentration, their acceptability levels are different and their odour impact should be also different. To evaluate this relative impact, odour concentration and acceptability level have been multiplied to obtain the annoyance potential.
The Figure 2 described these results.

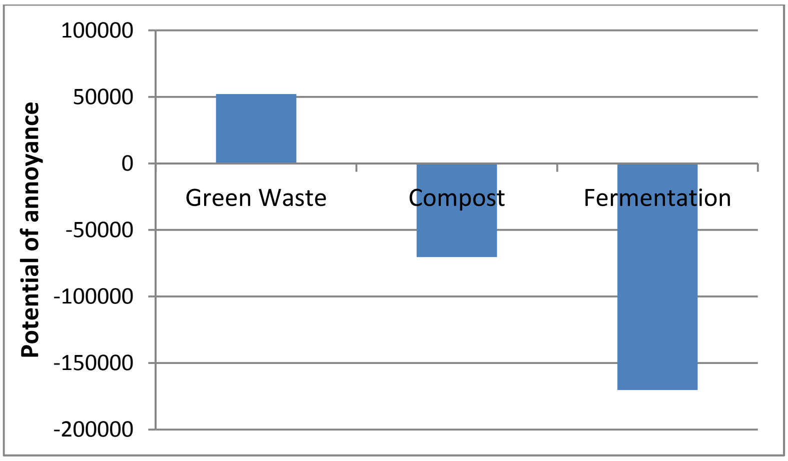

Figure 2: Potential annoyance for the three considered sources

This example shows that the use of the annoyance potential provides a more realistic view of the impact of these sources on the neighbourhood. Fermentation has a clearly more negative impact on the neighbourhood than the other sources. Furthermore, green waste odour is considered as an acceptable odour in comparison with anethole or limonene (Figure 1), and should not generate any olfactory discomfort.

3.2 Samples from building materials

This method was applied to building materials odours. Indeed, manufacturers face with odour problems in new products developments. This method can be applied to choose the process that lead to the material with the less odorant impact.

Two materials were tested. The experimental treatment consisted in introducing the samples of materials into Nalophan® bags, filling the bags with dry clean air, waiting for thermodynamic equilibrium (one week for each sample), and finally measuring the odour concentration and the acceptability level according to the method previously described. The results are mentioned in Table 3.

Table 3 : Odour concentration and acceptability of two building materials

	Odour concentration (ou_E/m^3)	Acceptability level
M1	1423	-1.18
M2	1158	-4.35

Then, the two values have been multiplied to determinate the annoyance potential (Figure 3).

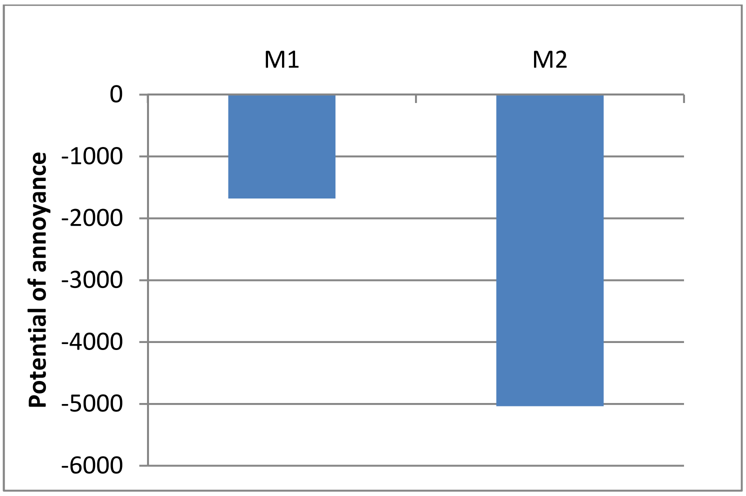

Figure 3: Annoyance potential of two building materials

The odour concentration of M2 is lower than M1 whereas its potential of annoyance is higher. This results in a significantly higher odour annoyance potential.

These two examples illustrate the fact that different kinds of sources, with similar odour concentrations, can be effectively discriminated by their acceptability levels.

3.3 Samples from composting and rendering plants

Table 4 presents the odour concentrations and acceptability levels of three gaseous samples: two coming from a composting plant (Lagoon and fermentation), and one from a rendering plant (biofilter exhaust). These samples have significantly different odour concentration, and that is, most often, the basis of their ranking (EN 13725).

Table 4 : Odour concentration and acceptability of a lagoon, a fermentation step and a biofilter exhaust

	Odour concentration (ou_E/m^3)	Acceptability level
Lagoon (composting)	70 340	-13,84
Biofilter exhaust (rendering plant)	64 274	-9,65
Fermentation (composting)	81 204	-6,93

Following this rule, fermentation has the most important impact in comparison with lagoon (composting) and biofilter exhaust (rendering plant).
If we consider the annoyance potential as grading factor to evaluate the impact of these odours, the obtained ranking is different (Figure 4).

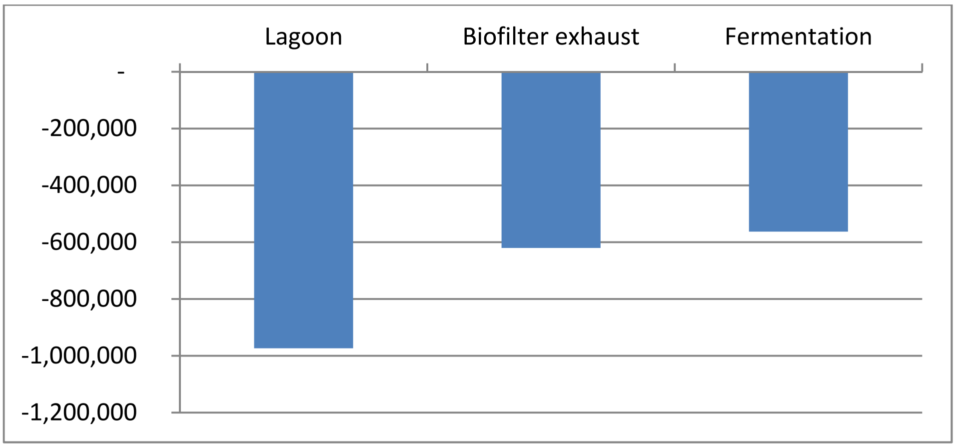

Figure 4: Annoyance potential for the three considered sources

The fermentation has the lowest impact despite its highest odour concentration, whereas the lagoon appears as the most impacting source.

4. Conclusion

In this study, a new method to determine consecutively odour concentration and acceptability is proposed. It allows calculating an odour annoyance potential by multiplying this two parameters. The interest of this approach lies in the fact that it permits a more realistic ranking of odour sources. This ranking could be considered after a data collection period.
Nevertheless, this method must be tested in many situations to estimate its sensitivity, reproducibility and robustness.

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