Atmospheric Environment 181 (2018) 54–60

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Odour assessment in the vicinity of a pig-fatting farm using field inspections (EN 16841-1) and dispersion modelling

Dietmar Oettl[a,*], Michael Kropsch[b], Michael Mandl[c]

[a] Air Quality Control, Government of Styria, Landhausgasse 7, 8010, Graz, Austria
[b] Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, Agricultural Research and Education Center Raumberg-Gumpenstein, Raumberg 38, 8952, Irdning, Austria
[c] Chemistry and Environment, Government of Salzburg, Michael-Pacher-Straße 36, 5020, Salzburg, Austria

ARTICLE INFO

Keywords:
Odour
Field inspections
EN 16841-1
GRAL
Odour-hour assessment
Concentration-variance model

ABSTRACT

The assessment of odour annoyance varies vastly among countries even within the European Union. Using so-called odour-hour frequencies offers the distinct possibility for either applying dispersion models or field inspections, both generally assumed to be equivalent. In this study, odour-hours based on field inspections according to the European standard EN 16841-1 (2017) in the vicinity of a pig-fattening farm have been compared with modelled ones using the Lagrangian particle model GRAL, which uses odour-concentration variances for computing odour hours as recently proposed by Oettl and Ferrero (2017). Using a threshold of 1 ou m^{-3} (ou = odour units) for triggering odour hours in the model, as prescribed by the German guideline for odour assessment, led to reasonable agreements between the two different methodologies. It is pointed out that the individual odour sensitivity of qualified panel members, who carry out field inspections, is of crucial importance for selecting a proper odour-hour model. Statistical analysis of a large number of data stemming from dynamic olfactometry (EN 13725, 2003), that cover a wide range of odorants, suggests that the prescribed method in Germany for modelling odour hours may likely result in an overestimation, and hence, equivalence with field inspections is not given. The dataset is freely available on request.

1. Introduction

In 2017 a new European standard has been issued (EN 16841-1) providing a method for assessing so-called odour hours by field inspections, whereby an odour hour is defined by at least 6 min of detectable odour concentrations. One aspect of the study presented herein was to test the practicability of this new European standard for regulatory purposes.

Only in a few European countries odour-hour frequencies are the standard assessment method (Brancher et al., 2017). In most countries (e.g. Belgium, Netherlands, Ireland, France, UK) the 98th percentile of hourly-averaged odour concentrations over an entire year is utilized. It has to be said that dispersion modelling is the only method that can be used for assessing 98th percentiles. Modelling, though, is limited to cases, where odour emissions are well known with regard to their strengths, locations and types (e.g. point, diffusive) of release. The concept of odour-hours (applied for instance in Germany, Lombardy, and Austria) allows for both field inspections (EN 16841-1) and dispersion modelling (not regulated at European level by now). Therefore, another objective of this work was to examine whether, and under which conditions, dispersion modelling provides equivalent results to field inspections. It should be recalled that dispersion models typically provide mean concentrations for an averaging time of one hour, owned to their inherent turbulence parameterizations. However, modelling odour hours requires the determination of the 90th percentile (corresponding with 6 min of perceivable odour within one hour) of the corresponding cumulative frequency distribution of odour concentrations. Often the 90th percentile is normalized by the hourly-mean concentration by defining $R_{90} = C_{90}/\overline{C}$, where $\overline{C}$ is the hourly-mean odour concentration, and C_{90} the 90th percentile. Various approaches can be found in literature for calculating R_{90}. In Germany, the regulatory odour dispersion model AUSTAL2000G (GOAA, 2008) uses the simple relationship $R_{90} = 4$, which is based on the work of Janicke and Janicke (2004). Piringer et al. (2016) use an empirical approach for assessing R_{90}, which depends on atmospheric turbulence and the distance to a (point) source. Recently, Oettl and Ferrero (2017) developed a model for R_{90}, which is based on the concentration-variance distribution. Both the German approach and the one of Oettl and Ferrero (2017) have been implemented in the Lagrangian particle model GRAL (Oettl, 2017a), which is used in this work for comparison purposes with

* Corresponding author.
E-mail addresses: dietmar.oettl@stmk.gv.at (D. Oettl), michael.kropsch@raumberg-gumpenstein.at (M. Kropsch), michael.mandl@salzburg.gv.at (M. Mandl).

https://doi.org/10.1016/j.atmosenv.2018.03.029
Received 2 January 2018; Received in revised form 9 March 2018; Accepted 12 March 2018
Available online 13 March 2018
1352-2310/

field inspections that have been carried out in the vicinity of a pig-fattening shed in Styria, Austria.

Another important issue dealt with in this study concerns the odour concentration above which odour can be perceived and recognized by qualified panellists during field inspections. By definition, an odour concentration of 1 ou m^{-3} (ou = odour unit) can be detected by 50% of a qualified panel of observers working in an odour-free laboratory using odour-free air as the zero reference. In real world, background odour concentrations from other sources than the one investigated and fast adaptation of the human nose, when continuously exposed to the same type of odour, may increase the threshold above which odour can finally be detected. The recognition threshold is generally assumed to be 1–5 ou m^3 depending on the type of odour (van Harreveld and Jones, 2001). Clearly, the odour-concentration threshold used in dispersion modelling when assessing odour hours has a large impact on resulting odour-hour frequencies. In Germany, a threshold of 1 ou m^{-3} is applied for C_{90} and it is stated in GOAA (2008) that in combination with $R_{90} = 4$ modelled odour-hour frequencies are equivalent with odour-hours deduced from field inspections, i.e. EN 16841-1. However, several presentations given at the VDI conference in Karlsruhe, Germany, in 2015 revealed large discrepancies between observed and modelled odour-hour frequencies (e.g. Grotz and Zimmermann, 2015; Hartmann and Borcherding, 2015; Oettl and Oitzl, 2015). Therefore, another objective of this study was whether setting a threshold of 1 ou m^{-3} is suitable for odour-hour modelling or not.

In the following, the experimental layout, the methods applied for the field inspections and the modelling are outlined in detail.

2. Description of odour-assessment methods

2.1. Field inspections

The European standard for field inspections EN 16841-1 requires at least a pool of eight panel members qualified according to EN 13725. Thereby, each participant must be able to detect a reference odorant (*n*-butanol) within a prescribed concentration range (20–80 ppb in case of *n*-butanol), which is calculated as an average over at least 10 and not exceeding 20 tests. In addition, the standard deviation needs to be below 2.3. Fig. 1 depicts the results of all candidates taken part in the study. Only 15 persons out of 23 tested, fulfilled the criteria set up by EN 13725 (2003), which are indicated by the grey rectangle. The large scatter visible in Fig. 1 indicates the usefulness of the selection procedure prescribed in EN 13725, as some of the candidates were not able to perceive the reference odorant adequately. Nevertheless, it becomes clear that a large pool of candidates is necessary for performing field inspections, which indeed can be very challenging for regulatory odour assessments.

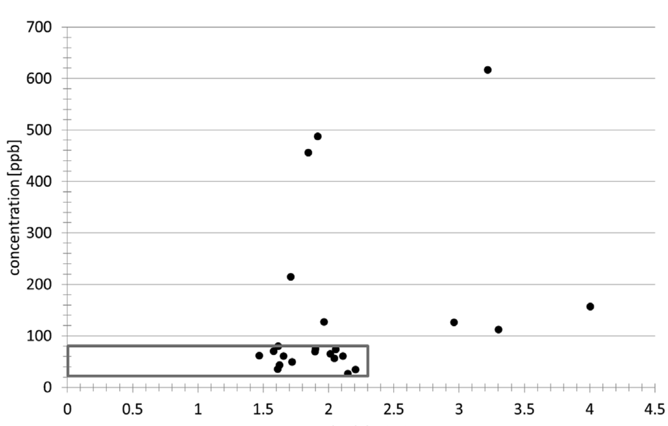

Fig. 1. Results of the dynamic olfactometry according to EN 13725 using *n*-butanol for each candidate participating in this study.

The field inspections started on 1 February and ended on 31 July 2017. A total of 52 observations were carried out at each one of the twelve measurement points (Fig. 2). An odour-hour is defined in EN 16841-1 by at least 6 odour detections during a 10 min sniffing time. Basically, the EN 16841-1 foresees the evaluation of odour-hour frequencies on a more or less rectangular grid by averaging four observations at the corners to get a mean value for the area in between, though, it allows for an evaluation of odour-hour frequencies at single points, too. As already outlined in the introduction, one objective of this study has been the comparison with dispersion modelling. Comparing simulations with observations at single points is stricter than it would be for averaged grid concentrations, as it requires a model to properly represent spatial concentration gradients more accurately. Typically, concentrations are quite non-homogenous, specifically in the very vicinity of sources and buildings, but often conflicts due to odour annoyance arise among neighbours living closely-spaced.

The maximum number of observational points assessed by a panellist during the field inspection is limited to 12 according to EN 16841-1. As the sniffing time at each point is 10 min, it took about 2.5–3 h to carry out the field inspection in our case, where the maximum number of observational points was chosen. Surveys have to be distributed evenly over the days, hours, and panellists (Table 1), which required a lot of planning in particular in case of illnesses or other unforeseeable events preventing a field inspection at a scheduled date and time. Inspections in winter time, between midnight and the early morning hours, and on weekends were naturally irksome. Unfortunately, there is no exception foreseen in the EN 16841-1 for skipping field inspections on weekends. From the meteorological point of view there is clearly no need to include weekends, unless the odour release is different on weekends than on working days. For instance, most agricultural odour sources are not varying with weekday, hence, it would improve the practicability of field inspections a lot, if inspections on weekends could be shifted and evenly distributed over the working days.

The experimental set up is illustrated in Fig. 2. Field inspections took place in the vicinity of a pig-fattening shed with a total of 1225 pigs on average. The mean weight of the pigs was 65 kg over the entire period as each compartment was charged on different times with piglets. The air sucked off from each compartment is collected in one channel and finally released via six chimneys (each 0.8 m in diameter) 8.5 m above ground level and 1.5 m above the roof top (gable roof). Next to the shed is an open manure storage tank 17 m in diameter, which had to be taken into account in the dispersion modelling, too.

The positions of the observational points were determined on the bases of expected main wind directions, evaluated a couple of weeks before the beginning of the field campaign using locally observed wind data. A few points were placed very close to the odour sources (P1 was in less than 10 m distance from the shed) and some were situated at larger distances (P9 was more than 300 m away from the shed) to enable subsequent model evaluations for the near and far field, respectively.

Apart from a small hill southeast of the shed rising approx. 40 m above the valley floor, the area is almost perfectly flat. A small river, accompanied on both sides by bushes and trees up to about 10 m, traverses the area north of the shed in west – east direction.

2.2. Dispersion modelling

For the simulations performed within this study the GRAL 17.9 model was applied. A comprehensive description of the model as well as its evaluation can be found in Oettl (2017a). The model is freely available (http://lampx.tugraz.at/~gral/) and consists of a prognostic microscale flow-field module to account for obstacles and a Lagrangian particle model for the dispersion of non-reactive pollutants. Both modules have been extensively tested and evaluated (e.g. Berchet et al., 2017a,b; Rollings, 2017; Manansala, 2017; Oettl, 2015a,b,c; Oettl,