CURRENT APPROACHES FOR ODOUR MODELLING AND UK OPPORTUNITIES FOR IMPROVEMENT

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INTRODUCTION

There is a fundamental difference between the requirements of modelling odour compared to modelling other 'classical' air pollutants. Odours can be perceived over a few seconds, whereas most dispersion models are designed to calculate 'ensemble mean' concentrations, typically hourly means (*EA, 2002*). The effects of odour fluctuations about the 'ensemble mean' can be modelled explicitly (the validation of which requires examination in itself) , or it can be incorporated empirically into statistical relationships between 'ensemble mean' concentrations (e.g. 98th percentile of hourly means) and community impacts (*Miedema, H.M.E., 1992*).

The aim of modelling odour also differs in that we are not just concerned with predicted exposure, but additionally in correlating odour exposure with the likelihood of adverse human responses such as annoyance and nuisance, as illustrated in Figure 1 (*Miedema, H.M.E.*, 2000). These responses are culture-specific, which presents further challenges in terms of international harmonisation.

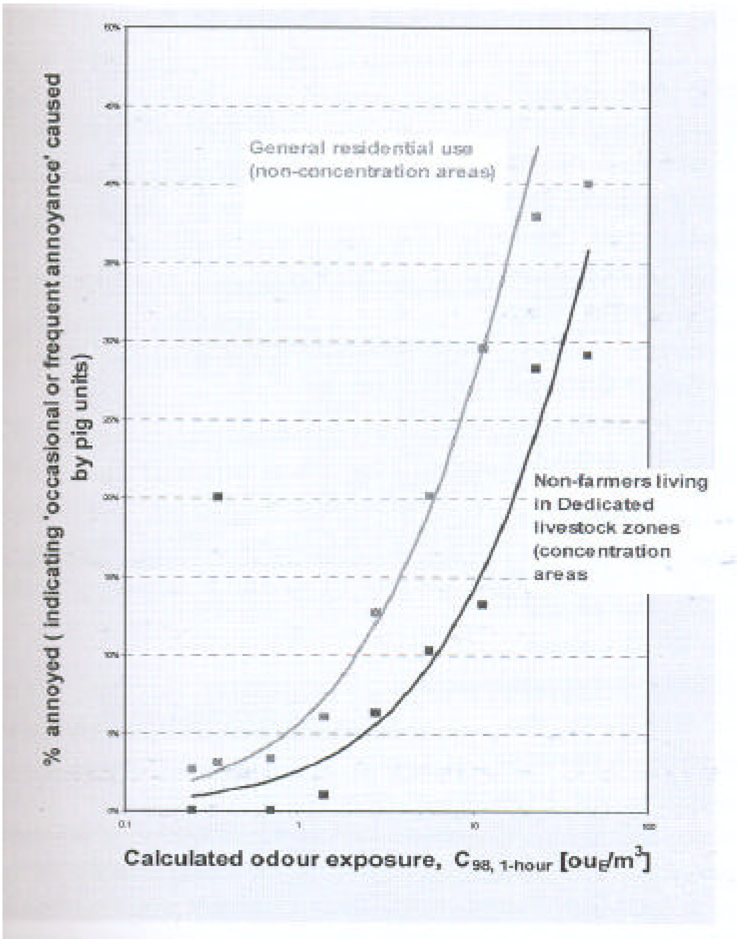

Fig. 1; Dose-response relationship for livestock odours in The Netherlands (Bongers et al. 2001)

There are different approaches around the world for using dispersion modelling as a tool for assessing odour impact. The evidence-base for many of the commonly-accepted assumptions in UK odour modelling/assessment is critically examined.

Dispersion models are being pushed to, and perhaps beyond, their limits when applied to odours. As modelling harmonisation is increasingly achieved between practitioners for the traditional pollutants, new and far more subjective issues need to be considered when modelling odours.

SOURCE STRENGTH

A dispersion model requires the odour source strength as a key input. The most reliable value for this input could, in theory, be determined from a large number of periodic, dynamic dilution olfactometric (DDO) measurements, for example, on a single existing chimney, where the release is controlled, continuous, and does not vary with time or process cycle. The uncertainty escalates sharply for estimated odour emission rates (e.g. for a proposed process), time-varying emissions, multiple sources on a site, and when specific compounds are used as surrogates for the total odour.

DDO is not currently practical on a continuous basis for any source. The inability to accurately quantify the odour's temporal variation, and difficulties in correlating the source variation with time-varying meteorology in the dispersion modelling, is the most significant source of uncertainty in the majority of odour assessments. The uncertainty on the source strength value can be several orders of magnitude even for commonly-encountered situations.

DISPERSION MODELLING OF EXPOSURE

It is important to recognise that the uncertainty on modelling some types of odorous release (e.g. diffuse/fugitive area sources, non-vertical vents) are very large. In such cases, the use of dispersion modelling as an assessment tool should be questioned.

The results of different, new-generation models can vary by up to a factor of 8, for high percentile calculations with significant building wake effects (*Hall, D.J., et al.*, 1999; *EA*, 2000 (b)). Examination of the range of results provides a sensitivity analysis of the model algorithms, and provides greater confidence in any regulatory decision. Dispersion modelling is usually carried out when the risk of odour annoyance is high. Under these circumstances, the use of more than one dispersion model can be justified for a risk-based approach (*Fisher, B.* , 2001).

The differences between the predictions of different models are important, because the 'Indicative Odour Exposure Standards' (*EA*, 2002) were set on the basis of results from a particular type of dispersion modelling exercise (based on an 'old-generation' model) in the Netherlands (*Miedema, H.M.E.*, 2000). Different (i.e. 'new-generation') models are now used in the UK and elsewhere for odour assessment (*EA*, 2000 (a)).

There is an urgent need to verify, for UK situations, the Dutch dose-response relationship which was established historically for livestock units (*Bongers, M.E., et al.*, 2001). The urgency arises because almost no details are available on the dispersion model which was used to establish this empirical dose-response curve, nor the input data for that modelling. Of particular concern is the reliability of the source strength data which were used for the Dutch modelling.

Dispersion models are currently in practical use only for predicting 'ensemble mean' (typically hourly mean) concentrations (*Dyster et al*., 1999). Fluctuation modelling (*Lee, J. and Stewart, J.R.,* 1999) is not yet adequately validated in field/community studies. As long as this remains the case, the approach for odour assessment commonly adopted in the UK (i.e. hourly mean modelling compared against an empirical benchmark) must remain the only feasible option.

Detailed guidance on best practice for dispersion modelling has been published (*ADMLC*, 2004). Most of the guidelines are applicable to odour modelling. Also, some uniformity in the way that model sensitivity and uncertainty are expressed by different practitioners is desirable.

CORRELATION WITH ANNOYANCE

Draft Technical Guidance Note H4 (*EA*, 2002) describes an approach to assessing and regulating odour impacts, involving quantifying odour emissions, dispersion modelling to estimate odour exposure, followed by correlation of exposure with the expected degree of annoyance using 'Indicative Odour Exposure Standards'. The approach can be used directly to assess the annoyance impact of an installation.

There has to be confidence that the Indicative Odour Exposure Standards really do represent '*no reasonable cause for annoyance*' for the given situation. This requires a review of how the Indicative Odour Exposure Standards were derived, and how applicable they are to the situation being modelled.

If a series of dose-response studies are carried out under UK conditions, it would allow the repeatability of the Draft H4 method to be estimated. The use of a calibration curve derived from Dutch livestock odours, and applying it to other odours and other types of installation in different countries, presents an additional layer of uncertainty compared to deriving a modelling guideline from a bespoke, dose-response study.

However, the level of annoyance measured by the survey in New Zealand (*Ministry for the Environment NZ*, 2003 & 2002) was found to be consistent with the Dutch odour dose-community-response curves. The dose-response curves, although developed for other industries and using a Dutch community response, appeared to be valid for pulp mill odours in New Zealand.

CORRELATION WITH NUISANCE AND COMPLAINTS

The EPA 1990 contains no technical definitions of nuisance, such as maximum concentrations, frequencies or durations of odour in air. Complaints are usually measured directly by complaints monitoring, rather than being predicted. However, dose-response studies using complaints as the response measurand have been carried out in New Zealand and Australia (*Perth*, 2002), but using different models to those in common use in the UK, and using different percentiles to describe exposure.

The uncertainties in correlating predicted exposure with either nuisance or complaints levels would be considerably higher than for annoyance, due to the additional factors involved.

CONCLUSIONS

There is a need to examine the uncertainties at every step of an odour impact assessment, from the definition of the source strength, through dispersion modelling, to the appropriate assessment criteria. To date, methodologies in the UK have relied upon limited research undertaken abroad, and there is an urgent need for dose-response studies for key industrial and agricultural sectors in the UK. These herald more immediate progress in odour assessment methodology for UK practitioners, compared to the longer-term prospects of field validation of fluctuation models.

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