

TECHNICAL NOTE

Discontinuous odour sampling in ambient air : not valid for characterising the odour impact



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Readership

Professionals faced with a need to assess an odour impact (impact of emissions on the vicinity) in ambient air.

Object

This note is a concise presentation of the scientific, technical and instrumental aspects that cast doubt upon the validity of discontinuous measurement of odours in ambient air for the purpose of characterising the odour impact.

Context

Odour perception is the outcome of an instantaneous stimulus lasting 3 to 5 seconds, i.e. the duration of a breath intake. The human sense of smell is thus sensitive to concentration variations over short periods.

Many professionals wish to take samples or run discontinuous odour measurements in ambient air for various purposes: determining the neighbours' exposure levels, measuring odour treatment equipment performance, assessing the regulatory compliance of a plant, checking that continuous odour measurement equipment is operating properly, validating odour atmospheric dispersion models, etc.

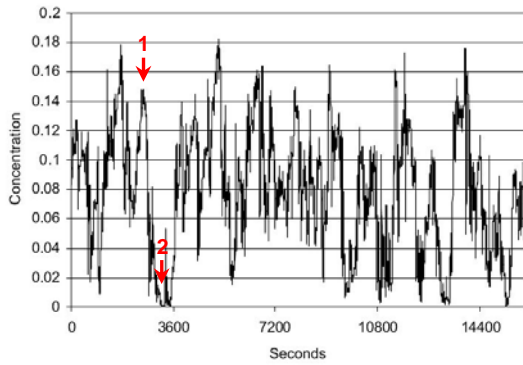
Atmospheric turbulence and concentration fluctuation

The planet's boundary layer is the approximately 1,000 metre-thick atmospheric stratum near the ground; it is the layer in which we live. Air flow within that layer is turbulent, given the constantly varying atmospheric parameters involved:

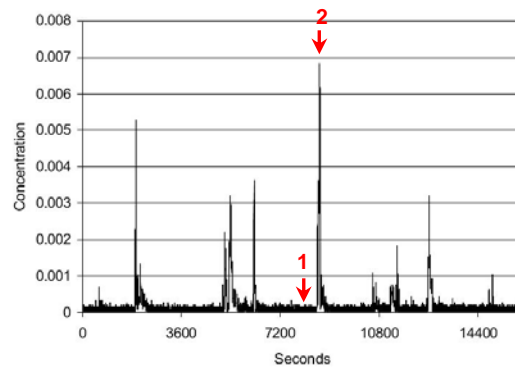
- The energy received from the sun : in the daytime, the Earth's surface is heated, and it heats up in turn the air layer directly above it, thus generating convection movements (vertical air movement); the convective movement ceases at night.
- The wind speed and direction fluctuations caused by the flow of air over ground objects (buildings, vegetation, hills, obstacles, etc.).

In summary, the atmosphere is in constant motion and is therefore dynamic. Because of the velocity fluctuations caused by turbulence, ambient air measurements at time t (in seconds) are not necessarily representative of measurements made one second later.

As an example, the following graphs show the variation over time of the odor concentration measured in a wind tunnel, for two types of emitting sources : (a) surface et (b) point. It can be seen that instantaneous measurements at a given moment (point 1) are not at all representative of the observations made shortly afterward (point 2). Indeed, measurements made at instant 1 in the case of point source (b) would undoubtedly indicate minimal concentrations, whereas in fact the exposure level is approximately 30 times higher a few seconds later.



(a) Observations of concentration fluctuations with a wind tunnel, for a surface (Best et al., 2001)



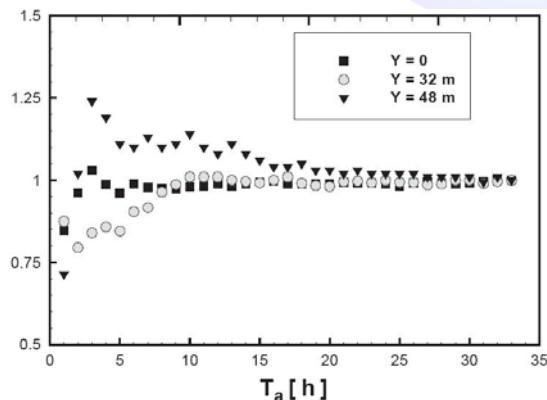
(b) Observations of concentration fluctuations with a wind tunnel, for a point source (Best et al., 2001)

Best P.R., Lunney K.E., Killip C.A. Statistical elements of predicting the impact of a variety of odour sources. Water Science and Technology, Vol. 44 No 9, pp 157-164, 2001.

Sampling frequency and duration

In order to represent the impact of odours within the atmosphere, concentration fluctuations over very brief periods corresponding to the rate of human respiration, i.e. 3 to 5 seconds (Aubrun et al, 2004), must be considered. Moreover, the length of the sampling period required to adequately portray the odour concentration fluctuations varies depending on where the sampled point is located relative to the odour plume. Indeed, as shown in the diagram below, a duration of 3 hours is required at a point in the centre of the plume ($Y=0$) in order to reach steady state, whereas the duration is 25 hours for a point at the edge. In order to represent an odour impact properly, instantaneous (to the second) and continuous measurements are necessary over a duration of 3 to 25 hrs for a single specific meteorological condition. However, meteorological conditions are obviously not constant over such a long period, given the daily cycle of the meteorological variables that control odour dispersion. A single discontinuous odour measurement or a few thus cannot characterise correctly the odour impact of one or more sources.

By using mathematical models appropriate for odours, however, the whole set of atmospheric conditions can be reproduced, and the concentration fluctuations due to turbulence can be characterised.



This graph shows the duration required to reach steady state (stability of the average) for points at the centre of an odour plume ($Y=0$ m) and at the edge ($Y=32$ m et $Y=48$ m).

Aubrun S., Leitl B. Unsteady Characteristics of the Dispersion Process in the Vicinity of a Pig Barn. Atmospheric Environment 38, 81-93, 2004.

Sampling – Technical considerations

Several technical problems and limitations may also occur with discontinuous measurement. The following points, for instance, must be taken into account :

Difficulties due to the location of measurement stations or points (for example, due to building effects or terrain obstacles causing recirculation zones, etc.) des obstacles terrain entraînant des zones de recirculation, etc.);

- Inadequate air sample collection duration (e.g. over a few minutes instead of 3 to 5 seconds). Odour samples must be collected in 20 to 60-litre Tedlar bags, and it is difficult to sample in less than 2 minutes with the equipment currently available on the market;
- High cost of multiple olfactometric analyses with many samples;
- Lack of quality control (data validation);
- Measuring instrument sensitivity (precision, resolution, calibration, etc.). The concentrations in ambient air are usually low, of the order of the equipment detection threshold or less.

Conclusion

It is becoming patent that all odour sampling and measurements effected discontinuously in ambient air are inadequate for quantifying the odour impact of one or more sources. There are two possibilities for determining the odour level in ambient air:

1. Measurement at the source combined with a dispersion model
2. Continuous measurement using electronic noses

Measurement at the source combined with atmospheric dispersion modeling gets rid of the problem of atmospheric fluctuations. Indeed, by measuring directly at the sources, contaminant concentrations are high and they are not dependent on atmospheric turbulence. Moreover, use of mathematical models accounting for the phenomena of physical dispersion and transport of pollutants in the atmosphere limits the uncertainty and yields results closer to reality.

Furthermore, measurements in ambient air are necessarily few in number (due to their high cost) and they are only representative of the spot where they are made. Depending on the local effects, the spatial and temporal representativity of a measurement point may be very limited. On the other hand, using a model one can generate data at a very large number of points and for very long periods.

In addition, it is far less costly to assess the odour impact by means of source measurements (for one or more sources) and of a dispersion model than with a multitude of spot measurements in ambient air.

Measurement in ambient air requires an operating time long enough to derive valid statistics. With an atmospheric dispersion model and a data base of meteorological conditions, the data required for statistical calculations are obtained much more rapidly (model computation time).

Moreover, impact scenarios can be generated by means of an atmospheric dispersion model, which is something no ambient air measurement can provide.

Measurements at the source can be effected by either spot sampling or electronic noses (e-noses), but e-noses are essential in the case of sources that have variable emissions. The sampling system of the e-nose meets the requirements of continuous measurement in order to ensure the quality of the measurements made.