# Odour potential

**As one of the developing aspects of odour management at sewage treatment plants, John Hobson reviews experience in the UK of working with quantitative techniques.**

With ever increasing pressure on the availability of land, new wastewater treatment works are having to be built in more sensitive locations and new building is encroaching ever nearer existing sewage treatment works. As a result, the issue of impact due to odour is assuming ever increasing significance. But it is possible, perhaps more so than many realise, to deal with the issue of odour in a quantitative manner.

Odour from wastewater treatment systems is a complex mix of organic and inorganic compounds. It is however difficult, expensive and not of particularly great value to try to quantify a wide range of these compounds. Exceptions include $H_2S$, because it is so easy to measure almost down to its threshold odour concentration, and compounds suspected to come from an odorous industrial discharge. A more generally useful measure of odour is odour strength as determined by olfactometry. Commonly assigned units are odour units per cubic metre (ou/m$^3$) - the number of dilutions a sample of air must receive until 50% of a selected test panel can detect no odour or fail to distinguish it from odour-free air.

Even more important than odour strength, however, is the concept of odour emission rate. For air leaving a chimney or a vent, this is simply the odour strength multiplied by the flow rate of air in m$^3$/s and has units of odour units per second, ou/s. Knowledge of odour emission rates allows for: the ranking of odour sources in significance; the use of a model of atmospheric dispersion to estimate ground level odour strengths which derive from an installation; and the use of both the above to develop an abatement strategy and define the duty for processes installed to treat odorous air.

Implied by the above is the existence of a numerical standard for odour quality. An example, developed in Holland, is 5 ou/m$^3$ or less for 98% or more hours. A dispersion model together with an appropriate file of meteorological data can demonstrate compliance or otherwise with this form of standard. It is unlikely that such a standard will be given legal weight, at least in the near future, but the demonstration of compliance with such a standard is one way of demonstrating that a proposed works will not give rise to adverse impact or nuisance and could become a planning requirement. Figure 1 is an example output of a site modelled under a single set of steady state meteorological conditions. Figure 2 demonstrates an output for estimating annual compliance with a possible odour standard, modelled using a file of one year's meteorological data.

For many processes used in sewage treatment, odours diffuse directly into the atmosphere and their odour emission rate cannot be easily split into a flow rate and an odour strength. To estimate an odour emission rate from such processes, less direct means must be employed as follows.

For area sources with air flow (eg diffused air activated sludge plant or odour biofilters), use a passive hood. The hood is placed over, or floated on, the source. The odour strength of the collected air is determined. The air flow-rate can be estimated from the process design.

For area sources with no air flow, use a hood with fan. This uses the same approach as above but this time odour-free air must be blown into the hood. The odour emission rate of the area covered by the hood is equal to the odour strength of the emitted air multiplied by the flow rate of air induced by the fan. The overall odour emission rate of the process is then calculated by scaling up from the area covered by the hood to the area of the process.

For any source, a micro-meteorological method can be used. An odour or $H_2S$ emission rate can be estimated by measuring a number of odour strengths or $H_2S$ concentrations downwind of a source. An atmospheric dispersion model is used, varying emission rate and other parameters until a fit of the decay of odour or $H_2S$ is obtained.

For most sources, an environmental wind tunnel can be used. This is a technique studied by WRc over the last 30 months and is believed to offer several advantages; it is described below.

Process modules are placed inside the wind tunnel and operated as normal. Air is blown over the surface of the process and the odour or $H_2S$ emission rate determined from the odour or $H_2S$ strength and volumetric flow-rate of the air leaving the wind tunnel. The dependency of the $H_2S$ emission rate on a number of process

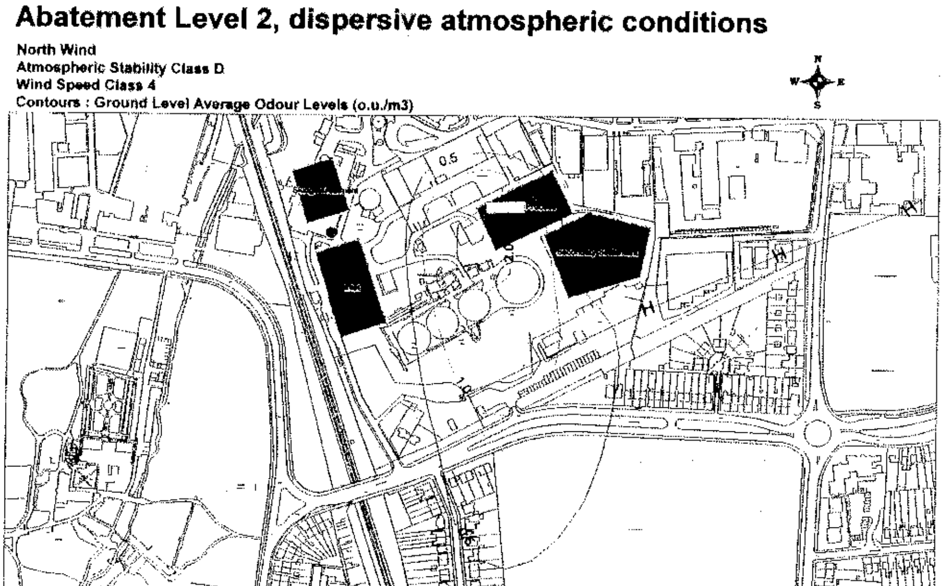


**Figure 1. Output of odour contours (ou/m$^3$), showing a relatively modest contribution to ground level odour from a highly abated works under favourable atmospheric conditions.**

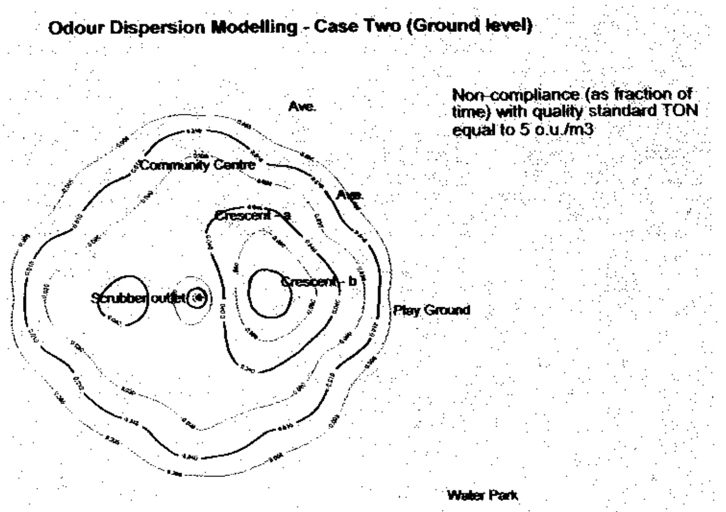


Figure 2. An output for estimating annual compliance with a possible odour standard, modelled using one year's meteorological data. This shows a 'hole' in odour frequency around the stack discharge point, a peak in odour frequency to the east reflecting the prevailing wind, and a lesser peak to the west reflecting the second most prevalent direction. Further afield, the standard is only breached under the most stable atmospheric conditions.

parameters was first determined, allowing the development of a model capable of predicting the $H_2S$ emission rate from each process studied. Once the form of each model was developed, a similar model was developed for odour by measuring the odour emission rate. Emission rates were found to depend on: wind speed; liquid flow-rate through the process; a number of process specific parameters such as area (tank surface) length (peripheral weir, filter distributor) height of drop (over weir or from a distributor) etc.; and the concentration of dissolved free $H_2S$ for $H_2S$ emission rates or odour potential for odour emission rates. Odour potential is a measurement of the level of odour associated with a liquid sample. It is the odour strength of air blown through the liquid sample in a standard apparatus. Odour potential is a valuable measurement in its own right, e.g. when carrying out an investigation into the causes of odour at a particular treatment works (see Figure 3) as well as being fundamental to estimating odour emission rates by this method.

Estimating odour emission rates from the models developed during this work has two positive advantages in particular, as well as overcoming difficulties with each of the other methods. For an existing process, odour abatement measures could include: collecting and treating odorous air - this probably involves covering the process; modifying the process to reduce e.g. turbulence or the height of fall over a weir; and treating the flow to reduce its odour potential (or altering upstream conditions to prevent an increase in odour potential). The value of each of these can be evaluated on a common basis using the models that have been developed. None of the other procedures for estimating odour emission rate could be used in this way.

At proposed sites, the odour emission rates can be estimated for planning purposes given data on the process dimensions, process flow-rates and the expected odour potentials of the process flows. WRc has built up a database of values of odour potentials that might be expected (see table below for well operated plant).

Some data on expected odour emission rates exist in the literature but this cannot be used to build up a predicted odour emission rate from a new works given the relevant design details and likely history of the process flows.

The overall procedure to quantify odour impact requires a measurement or estimate of odour emission rate, the use of a model to predict the contribution to ground level odour strength and an odour standard. When WRc used these combined procedures at a large sewage treatment works, the predicted area of adverse impact matched the area from which complaints were received very well. At two other sites with a significant odour problem, these techniques also predicted a very significant impact on the surrounding area. In each of these two cases a very variable odorous discharge came from a large industrial site and it

## Expected odour potential values

| | |
|---|---|
| Fresh crude sewage | up to 5000 |
| Settled sewage | up to 20,000* |
| Activated sludge mixed liquor | 2000 (nitrifying) 5000 (non-nitrifying) |
| Final effluent | up to 2000 |
| Crude sludge and sludge liquors | up to 5,000,000 |
| Digested sludge and sludge liquors | up to 200,000 |
| Raw sewage plus return liquors | up to 70,000 |
| Significantly septic sewage | around 100,000 ($H_2S$ > 1 mg/l) |
| Intensely septic sewage | up to 1,000,000 ($H_2S$ > 10 mg/l) |

* very much higher if tanks not effectively de-sludged or if flow includes added return liquors

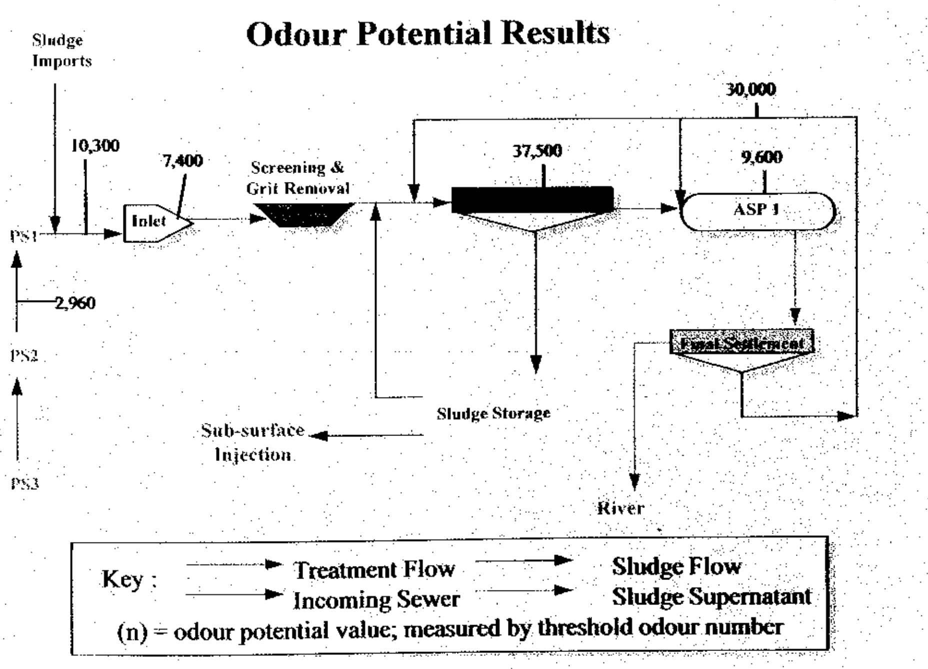


Figure 3. Odour potentials, showing the effect of sludge imports, a rise in odour in the primary tanks due either to stored sludge or the effect of surplus activated sludge, and a medium to highly loaded activated sludge plant which does not de-odorise its feed as well as it might and produces a somewhat unstable return sludge.

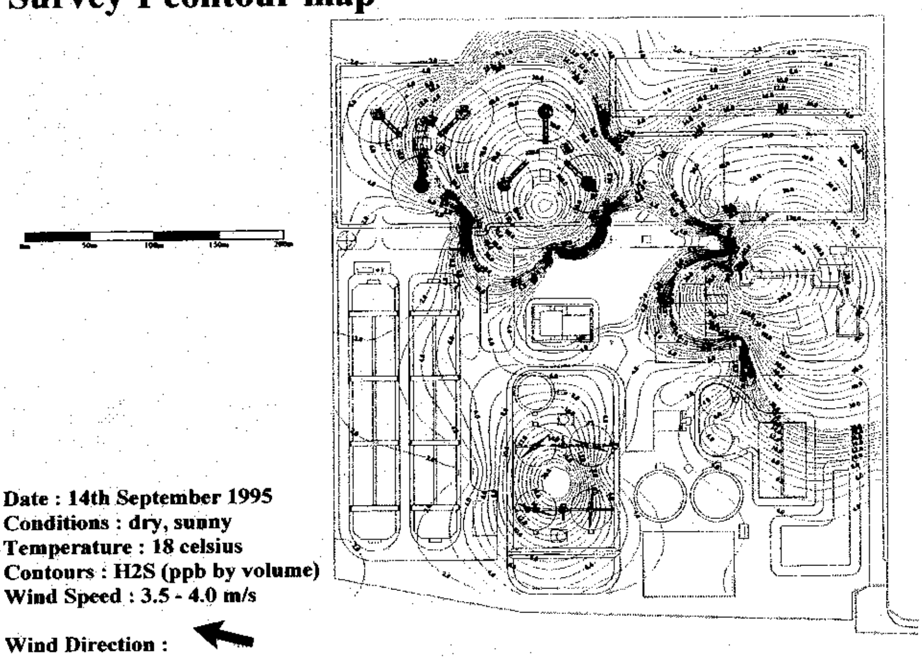


Figure 4. Example $H_2S$ map, showing high levels of $H_2S$ around some processes but with relatively rapid die-off on moving downwind. Such a map and model predicitons can be compared.

is quite likely that the worst cases modelled did not represent the worst case of odour in the industrial discharges.

It is also possible to compare concentrations of $H_2S$ predicted by these methods with an $H_2S$ map at ppb levels based on measurements around a site (see Figure 4). This is a form of micro-meteorological comparison. Where this has been done, predicted and measured $H_2S$ levels close to the processes agreed very well but the observed decay of odour downwind of processes was much more rapid than the model suggested. It is believed that buildings and structures within and around a sewage treatment works induce significant extra small scale turbulence into the atmosphere which dispersion models cannot easily represent. This could be a significant problem with the use of dispersion models to represent small scale ground-level dispersion and is even more of a problem with the use of micro-meteorological methods for estimating odour emission rates.

Odour issues tend to be sensitive and up to now WRc has not been able to publicly report any of this work. WRc is, however, currently starting a validation exercise of these techniques at a large works and hopes to be able to report this in the scientific or technical literature. ■


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# Europe moves towards standardisation on odour measurement

**A new European CEN standard for odour measurement is on target for introduction in 1998 after validation by an interlaboratory comparison on n-butanol, explains Ton Ph. van Harreveld.**

Of all complaints caused by environmental annoyance, odour remains a major cause. This is no surprise; the sense of smell is after all a sense that has the function to warn us of situations that might harm us and to guide us towards desirable stimuli.

Far removed from its evolutionary origin, the sense of smell is used as a basis for environmental policy and regulation. To balance interests of residents, industry and utilities, a numeric, objective expression of odour emissions is a requirement for licensing and public planning purposes.

To be able to measure smell, olfactometry has been used for a long time. With the environmental application, the need for a defined quality in these measurements become obvious.

The European Standards organisation CEN has taken the initiative to draft a European Standard on dynamic olfactometry, following earlier national standards in The Netherlands NVN2820 (1996), France (NF X 43-101, [illegible] and Germany (VDI 3881 blatt 2). The CEN working group CEN/TC264/WG2 'Odours' has now finalised the draft prEN document.

The document allows as much methodological freedom as possible, allowing three 'flavours' of presentation (single stimulus, forced choice, forced choice-probability). However the standard is very firm on setting both an accepted reference for the odour unit (equivalent to 40 ppb/v of n-butanol) and performance requirements for repeatability and accuracy based on ISO5725.

As a final step in the preparation of the standard, a validation of its quality criteria was required. To achieve this validation, an Interlaboratory Comparison for Olfactometry (ICO) was organised in the summer of 1996 with 19 laboratories from five European countries participating. The test substance was n-butanol in a concentration range from 15 to 400 ppm/v. From the qualified laboratories, 36% fulfilled the criteria on both accuracy (<0.217) and repeatability (<0.477). This result was discussed in the working group and it was decided that the criteria were attainable.

The draft CEN standard will be issued in November 1997 for public inquiry among the members of the CEN organisation, followed by voting in 1998. The standard, once it has been accepted, will be mandatory throughout the European Union, and replace earlier national standards.

The methodology proposed by the CEN working group CEN/TC264/WG2 'Odours' is already gaining a following in the field, with laboratories both in Europe and outside Europe (Malaysia, Hong Kong, Australia, New Zealand) adopting the CEN methodology.


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