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The Effect of Sampling on the Measured Odour Concentration

Anna H. Bokowa
ORTECH Environmental
804 Southdown Road, Mississauga, Ontario,L5J 2Y4,Canada

Odour is considered a nuisance in most jurisdictions in Canada, Australia and the United States. Some provinces and states have regulations for odour. For example in Canada the Ontario Ministry of the Environment (MOE) has a target odour concentration of one (1) odour unit (ou) at the property line or at any sensitive receptor. This is based on either measurement at potential odour sources and dispersion modeling to predict the off site odour concentrations or just ambient air measurements. In Queensland, Australia the requirement is even more stringent, requiring 0.5 ou for tall stacks or 2.5 ou for short stacks. How precisely can we measure or predict odour units? It is not possible to be exact with requirements such as 1 ou or 2.5 ou due to several factors such as: different, not necessary correct methodology used for odour sampling, especially for hot, humid sources or even at area sources, uncertainty in sampling for fugitive sources which might contribute significantly to off site odours. On the other hand, the emission rates are based only on a one time snap shot instead of continuous monitoring. Finally, the dispersion modelling itself has errors, as well. Therefore, for the same facility the off-site odour concentration might be 1 odour unit (ou),but could very easily be 10 odour units or higher.
This paper will introduce several studies showing significant differences in results when different sampling approaches are used.

Introduction

During an odour assessment, it is very important to consider all factors which may significantly affect the results. These include a careful selection of all potential odour sources in the plant including point, area and fugitive sources, as well as the techniques used for collection and evaluation of odour samples. Often, fugitive sources are omitted during the assessment and therefore the predicted odour concentrations are lower than the actual concentrations. The results from actual ambient measurements are dependent on emissions from all sources at the plant including fugitive sources. Therefore, it is very important to include them during odour assessments.
The other factor which might influence results is the methodology used for collection of samples especially at hot, humid point sources as well as area sources or ambient locations.

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Sampling Methods

In Ontario, Canada the sampling methodology is very strict and requires sampling at a dilution where the minimum loss of odours occurs. This is called the optimum predilution. The optimum predilution level is the dilution which results in the highest odour level, while still providing an odour in the sample bag that is strong enough to be reliably evaluated. Three samples are usually collected at each four different predilution levels. One sample at each dilution is evaluated, and the optimum level is selected. The remaining two samples at that dilution are then evaluated. Usually six out of twelve collected samples are evaluated for odour detection threshold value (ODTV).
Most states in the United States have no requirement for on site predilution to prevent any losses of odour. Instead, the lung technique is used for collection of undiluted samples.
The loss of odour may be very significant when undiluted samples are collected. Therefore, a predicted concentration of 1 ou may actually be much higher, depending on the sampling methodology used for the collection of samples at point sources, especially when they are hot and humid.
The same applies to the sampling methodology used for the collection of odour samples from area sources. A flux chamber technique is often used for sampling area sources. This technique is still a valid method for sampling area sources, but in recent years studies have shown that odour emission rates obtained when samples are collected using a wind tunnel technique are much higher than odour emission rates obtained by collection of samples using a flux chamber technique.
There are also different techniques used for assessing ambient odour levels. These techniques may have a significant effect on the test results. In most states in the United States, odour is still regulated based on the ambient levels which are obtained using instruments such as the Scentometer or Nasal Ranger.
In Ontario, the approved methodology for assessing ambient levels simply requires collection of samples at any ambient location, mostly sensitive receptors, and evaluation by an odour panel members using dynamic olfactometry.
ORTECH performed several studies involving use of the Nasal Ranger at the same time as ambient sampling and the results are presented in this paper. The Nasal Ranger gives a minimum of three times lower odour thresholds than the actual ambient sampling and odour panel evaluation.
There are several reasons why the Nasal Ranger instrument gives lower results such as background odour from foam used around the mask or insufficient charcoal units to purify the dilution air. Also the instrument procedures require that the operator breathes through the zero air filter for a few seconds prior to selecting the appropriate dilution ratio which allows them to detect the odour. This allows some recovery to take place but provides no assurance that the operator's nose has completely re-established its peak level of sensitivity. If the operator's sensitivity has not completely recovered, then odour levels recorded by the operator will be lower than they actually are. Unfortunately, it would not be possible to recalibrate the users nose through the use of a standard odourant such as n-butanol, because adaptation is specific to the odour to which the observer is exposed, and sensitivity to other odours is unaffected.

Other Factors Influencing The Results

Another significant factor influencing the results of odour testing is the time period between odour sampling and evaluation. It is important to evaluate samples as soon as possible, especially for samples collected from sources where hydrogen sulphide is expected to be present.
Different results may also be obtained by using different types of olfactometers for evaluation of the collected samples. It was noticed during several studies performed in Ontario. An example multiple station olfactometers when all the panelist perform the odour evaluation at the same time, or just one station olfactometers, when the evaluation is done one by one panelist.
When a one station olfactometer is used for evaluation purposes, there is a greater error in the results which may be due to several factors such as uncertainty in using the same dilution for all panelists, contamination of the olfactometer during so many changes to the dilution for each panelist, short mixing time (especially for high dilutions, when only a small amount of sample is required for evaluation). Frequently, when the one station olfactometer has been used for evaluation of the samples collected from the same source, the results have been much lower than the results obtained from the multiplied station olfactometer with a much longer mixing time.
During an international Round Robin testing of various olfactometers performed in 2003 it was shown that the one station olfactometer generally gave odour concentrations three (3) times lower for standard odourants than multiplied station olfactometers.

Case Studies

The following studies show a significant difference in results when different sampling techniques were used for the collection of samples from point sources, area sources or ambient sources.

Study 1
This study was performed at an automotive facility located in Ontario, Canada. Two of the tested sources had a very high temperature.
At Source 1, ORTECH collected three samples at each of: 60, 50, 40, and 30 times dilution. One sample at each dilution was analyzed and it was determined that the optimum dilution was 50 times. Two additional samples collected at this dilution were analyzed. At Source 2, three samples were collected at each of 40, 30 and 20 times dilution and, based on the evaluations, the optimum dilution was 30 times.
In addition to the predilution sampling, ORTECH also used lung sampling to collect undiluted samples.

Results- Study 1
The results for odour detection threshold values obtained when the two methods were used (dilution versus no dilution) for the two separate sources are presented in Table 1.
The odour detection values were determined at ORTECH laboratory using dynamic olfactometry and screened panelists according to the European standard EN 13725:2003

Table 1 - Summary of Results for Source 1 and Source 2

Sampling Location	Odour Detection Threshold Values (ou)		Factor
	Samples Prediluted	(Samples Undiluted)	
Source 1	34,294	2,075	16
Source 2	1,588	124	13

Based on the test results, the loss of odours was significant, and was recorded as thirteen to sixteen times, for the undiluted samples.
The lung sampling method for collection of samples from hot, humid sources is inappropriate, and therefore, the lung technique should not be used for such sources.

Study 2
Study 2, uses an example of sampling at a facility located in Ontario, Canada. ORTECH performed sampling at one of the area sources in order to demonstrate the difference in results when two different techniques were used for the collection of samples.
Location 1 and Location 2 were chosen at an open tank. ORTECH used a flux chamber at Location 1 and a wind tunnel at Location 2. After collection of the first set of samples at both locations, the samplers were placed in opposite locations: flux chamber at Location 2 and wind tunnel at Location 1. At each location three samples were collected using the flux chamber methodology and three samples were collected using the wind tunnel methodology.

Results- Study 2
Table 2 presents a summary of the emission rates for the area source when the two techniques were used for collection of the samples at the same time.
The results are based on data from three samples collected at each of the two different locations.

Table 2 – Summary of Odour Emission Rates for the Area Source

Odour Emission Rate* based on Wind Tunnel Method ou/s/m^2	Odour Emission Rate* based on the Flux Chamber Method (ou/s/m^2)	Factor
61.99	5.19	11

* based on collection of three samples at each of two locations

ORTECH studies showed a significant difference in the results when the flux chamber and wind tunnel were used at the same time at the same source.

The odour emission rates measured when the wind tunnel was used were eleven (11) times higher than the flux chamber odour emission rates. Both methods were used for the same area and during the same conditions.

Study 3

Study 3 presents the results for odour levels obtained when two different techniques were used for assessing ambient odours. Two different sites were chosen for the study: in the vicinity of paint, and coffee facilities. The first site was located downwind from a paint facility and the second site was located downwind from a coffee facility. At each site, two locations were chosen and at each location, three samples were taken using the lung sampling technique. After collection of the samples, all samples were analyzed at ORTECH's odour test facility using a dynamic olfactometer with eight screened panellists. The results obtained by this method were then compared with the actual readings taken by two panellists on site using the Nasal Ranger instrument. The readings were performed at the same times as when the lung sampling occurred.

Table 3 - Comparison of Ambient Odour Levels Using Two Methods – Paint and Coffee Facilities

Location	Sample Number	Odour Concentration determined by olfactometer ou	Nasal Ranger on site D/T	Ratio Odour Concentration in the Bag to Nasal Ranger	Nasal Ranger in the bag D/T
Site 1					
Location 1	Sample 1	48	7	6.9	4
	Sample 2	87	7	12.4	4
	Sample 3	73	7	10.4	4
Location 2	Sample 1	91	15	6.1	7
	Sample 2	86	15	5.7	7
	Sample 3	60	7	8.6	4
Site 2					
Location 1	Sample 1	26	4	6.5	2
	Sample 2	34	4	8.5	2
	Sample 3	48	4	12.0	NM*
Location 2	Sample 1	38	4	9.5	2
	Sample 2	52	4	13.0	2
	Sample 3	122	NM*	ND**	7

As shown in Table 3, results obtained by using the collection of bag samples with evaluation by dynamic olfactometry and screened panelists are much higher than the results obtained with the Nasal Ranger instrument by a factor of six or more.
After finishing olfactometer evaluations of the collected samples with the panelists, the same sample bags were analyzed by the panelists using the Nasal Ranger instrument. The Nasal Ranger was inserted into the sample bag and at the blank position the filtered air was checked for any odours following the procedure used on site.

Results- Study 3

The results presented in Table 3 for the Nasal Ranger readings in the bag indicated that the Nasal Ranger readings were lower by a factor of almost two when compared to the results of the Nasal Ranger readings on site, which is normal due to the fact that on site

the readings were taken at peak conditions, whereas readings in the bag represents an average for 10 minutes.
Results for odour levels in the collected ambient samples compared to Nasal Ranger readings obtained in the bag show even higher difference with a minimum of twelve (12) times difference. Therefore, there is a significant difference in the results, when these two methods are used for assessing ambient odours.

Summary Of The Results

The results of a study performed by ORTECH demonstrate the difference between using a predilution method and using a method which does not include predilution. In this study the difference was up to sixteen (16) times.
The odour emission rate measured with a wind tunnel was eleven (11) times higher than with the flux chamber.
The Nasal Ranger gives a minimum of three times lower odour thresholds than the actual ambient sampling and odour panel evaluation.

Conclusions

Compliance with an odour regulation such as a 1 ou limit is not demonstrated unless proper sampling methodology is developed, which should be followed by all consultants. The importance of proper sampling especially for point sources where the source is humid and hot is very important. The loss of odourant might be thirteen times or greater if proper methodology is not used. The lung technique should not be used for humid, high temperature sources and the dilution technique should be used when sampling at these sources.
When sampling at area sources, the wind tunnel technique is a preferred technique under same conditions where the wind may have some influence on emissions.
Lastly, when assessing ambient odour levels, the Nasal Ranger technique is much less reliable than the lung sampling followed by odour evaluation.
Finally, all fugitive sources must be included when assessing facilities for potential odour sources.

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