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Techniques for Odour Sampling of Area and Fugitive Sources

Anna H. Bokowa; Hong Liu
ORTECH Environmental; York University
2395 Speakman Drive, Mississauga, Ontario, L5K1B3, CANADA

There are several methods for assessing odours discharged from point sources such as stacks and vents. These methods are very well developed. However, odour emissions from area and fugitive sources are very difficult to assess. In US and Canada, the most common technique for assessing odours from area sources is a flux chamber technique which is recommended by the Environmental Protection Agency. However, this method is not a standard. Another technique used for assessing odours from area sources is a wind tunnel based technique. Due to the fact that this method is more complicated than the flux chamber technique, it is not as popular as the flux chamber method. This paper compares these two techniques. The results of odour emission rates when the two techniques are applied showed that the flux chamber method underestimates the odour emissions from an area source by a factor of 12 to 16 times. This method can only be applied during stable wind conditions. This paper also introduces a method developed for assessing the odours emitted from fugitive sources such as open doors and transport trucks. The estimation of odour emissions from fugitive sources is based on the assumption that odours are very well mixed within the cavity area attached to a building or structure. Once the odour concentrations are measured within the cavity region, the odour emission rates from the fugitive sources can be back-calculated using an air dispersion model such as SCREEN3 model. This method has been verified using field measurements.

Introduction

Different counties follow different approaches for odour sampling. In 2003 the European Standard EN:13725:2003 . "Air quality-Determination of odour concentration by dynamic olfactometry" was released but in this standard there is limited information on how to sample for odours. This standard puts more emphasis on the analysis of collected samples using a dynamic olfactometry.

But how good is the analysis if the samples are not collected properly?

There is a need for a standard method similar to European Standard EN: 13725:2003 which should include step by step sampling procedures for odours with the emphasis on sampling for area and fugitive sources.

In Ontario, Canada, compliance sampling for odours should follow the MOE's Draft Source Sampling for Odours, Version #2, February, 1989. This guideline outlines sample collection protocols and references the MOE's Source Testing Code (November

1980) for stack gas velocity, volumetric flowrate and moisture determination procedures. However, over the few years, the MOE is proposing some changes to the Draft Source Sampling for Odours method.

In the US there is no specific sampling methodology for collecting samples for odour from point sources and fugitive sources. There is only an EPA flux chamber method for assessing odours from area sources. The lung method is still used for collecting odour samples, which basically is based on collecting an undiluted/grab sample from any point source. This method is not acceptable in Ontario, Canada, especially for moist sources, elevated in temperature sources, when there is a potential for condensation, chemical reaction or oxidation and, therefore, a significant loss of odour. The loss of odour might be up to sixteen times when the samples are not taken properly.

Sampling for area sources or fugitive sources is even more confusing based on the fact that odour emissions from these sources are more difficult to quantify.

Therefore, there is a need for proper sampling protocol used by all countries for assessing odours from any sources.

It is very common for only one or two samples to be collected per source, to reduce the cost of the project. However how can anyone propose the installation of very expensive odour control equipment when a proper assessment is not performed? It is unrealistic to design a program to reduce odour based on a limited number of samples or not using a proper methodology during sampling. A careful selection of the sampling procedures should be performed before any project commences.

This paper idescribes the two sampling methodologies used for assessing odours from area sources as well fugitive sources such as doors, windows and transport trucks.

Methodology

Sampling Technique for Area Sources
There are two commonly used methodologies for assessing odours from area sources- the flux chamber technique and wind tunnel technique. The standard US EPA flux chamber encloses an area of 0.13 square meters of the liquid or solid surface. Nitrogen is used as the sweep gas, and is metered through the flux chamber at a rate of two to five litres per minute. Nitrogen flow in the flux chamber is distributed through a perforated ring of Teflon tubing around the inner perimeter of the chamber, about one-third of the way up the chamber. The sample is collected in a sampling "lung" using the same two to five litre per minute rate. However if the odour is expected to be high, the odour sampler with a dilution system should be attached to the line and the sample should be diluted on site during the collection of the samples in order to prevent any loss of odour. However in most states in the US, the dilution technique is unknown and samples are collected undiluted which might result a significant loss of odour. Triplicate samples are collected at one location for odour analysis. However this technique is used for collection of samples under very stagnant conditions due to the fact that sweep gas flow is very low.

There is a second method for collecting samples from area sources such as a portable wind tunnel technique. The portable wind tunnel technique provides odour emissions as a function of wind speed, where as the flux chamber operates at negligible wind speeds. However, for reasons such as difficulty in finding clean air for diluting samples or setting up that equipment, most of the consultnts performing odour sampling avoid using the wind tunnel technique. However, based on the several studies, it has been shown that that tehnique is more appriopate for assessing odours from area sources.

There are several designs of wind tunnels. However, for our comparison study a Lindval portable wind tunnel was used with a surface area of 0.33 square metres and a velocity set at 0.3 m/s.

Case Study - Flux Chamber Method versus Portable Wind Tunnel Method
A clean, filtered air was introduced into the wind tunnel at the velocity of 0.3 m/s. The air was mixed with emissions from the source surface. Concentrations in the exhaust stream and the air velocity at the sampling point were used to estimate the odour emission rate. For each sampling location (two locations), three samples were collected and analyzed for odour detection threshold values. These values with the estimated flow rate (based on the velocity and open area) were used for calculation of the emission rates.

ORTECH studies showed a significant difference in results when the flux chamber and wind tunnel were used at the same time at the same source. Table 1A and Table 1B present the results for both techniques used for collection of the samples.

Table 1A Odour Detection Threshold Values
Thickener Vessel-Wind Tunnel Method

Date Sampled	Sample No.	Predilution Ratio	Raw Odour Detection Threshold Value ODTV ou	Net Odour Detection Threshold Value ODTV ou	Geometric Mean ODTV ou
	25490-B119	1	724	724	
	25490-B120	1	845	845	
Location 1	25490-B121	1	819	819	
					756
Location 2	25490-B122	1	724	724	
	25490-B123	1	709	709	
	25490-B124	1	724	724	

Odour Emission Rate = 61.99 ou/s/m^2

Table 1B Odour Detection Threshold Values
Thickener Vessel-Flux Chamber Method

Date Sampled	Sample No.	Predilution Ratio	Raw Odour Detection Threshold Value ODTV ou	Net Odour Detection Threshold Value ODTV ou	Geometric Mean ODTV ou
	25490-B125	20	985	19700	
	25490-B126	20	826	16520	
Location 1	25490-B127	20	738	14760	
					19864
Location 2	25490-B128	20	1158	23160	
	25490-B129	20	1192	23840	
	25490-B130	20	1158	23160	

Odour Emission Rate = 5.19 ou/s/m^2

There was a significant difference in emission rates between wind tunnel technique and flux chamber technique. The emission rates obtained by the wind tunnel technique are eleven times higher.

Sampling Technique for Fugitive Sources

Quantifying odour emisions from fugitive sources such as doors, windows and transport trucks, is one of the challenges in addressing odour issues in the regulatory setting. The odour emissions from doors, windows and transport trucks (trucks are treated as buildings or structures), are generally trapped within cavities attached to the buildings or structures due to negligible plume rise. The authers have developed a methodology for quantifying the odour emisions from these fugitive sources which is based on the assumption that the odour is very well mixed within the cavity region attached to a building or structure due to its turbulent nature. A reference paper is included in this paper under the reference section.

The methodology includes three steps. The first step is to take the undiluted ambinet odour samples using the lung technique within the cavity of a building or structure. The concentration within the cavity region is not very sensitive to the meteorological conditions, based on the building downwash algorithms employed by the SCREEN3 model. The ambient odour concentration within a cavity region is relatively easy to measure.

Once the ambient odour concentration within the cavity is measured, the second step is taken to backcalculate the emission rate using SCREEN3 model. The SCREEN3 model has algorithms to calculate the concentrations within the cavity. These algorithms are used to back-calculate the odour emission rate based on the ambient odour concentration. In order to calculate the cavity concentration, the fugitive emission has to be modeled as a point source. Accordingly, a pseudo-point source with very low plume rise, i.e., with the exit velocity set to 0.001 m/s, exit diameter set to 0.001 m, exit temperature set to ambinet temperature, and stack height set to average realse height, is modelled to represent the fugitive emissions from doors, windows and transport trucks.

Once the SCREEN3 model is run, a dilution factor using the ratio of unity emission rate to the cavity concentration predicted by SCREEN3, is calculated in Equation 1:

$$Dispersion\ Factor\ (m^3\ /\ s) = \frac{Unity\ Emission\ Rate\ (ou\ /\ s)}{Cavity\ Concentration\ (ou\ /\ m^3)} \quad (1)$$

The fugitive odour emission rate is then calculated using Equation 2:

$$Odour\ Emission\ Rate (ou\ /\ s) = Dispersion\ Factor\ (m^3\ /\ s) \times Ambient\ Odour\ Concentration\ (ou\ /\ m^3) \quad (2)$$

The third step is to validate the results by using one of the following two approaches:

(1) measure the odour emission rate if the fugitive emissions could be consolidated into a vent or stack by creating negative pressure to the doors or windows; and

(2) carry out a combined analysis between the measured ambinet odour concentrations and modelled cocnentrations at the downwind distances using the estimated odour emisison rate as input to an air dispersion model if the fugitive emissions could not be consilidated.

ORTECH has applied this methodology for a few facilities in Canada. Table 2A shows the result using the first validation approach for a waste processing facility with a receiving door as the dominat source. Table 2B exhibits the result using the second validation approach for another waste handling facility with emissions from receiving doors, transport trucks and biofilters. Clearly, these results give us confidence in the methodology.

Table 2A: Comparison of Odour Emission Rates Estimated Using Two Methods

Process	**Ratio of Odour Emission Rate Estimated from Stack to that Estimated from Receiving Door**
Process 1	1.10
Process 2	0.98

Table 2B: Combined Analysis of Modelled and Monitoring Odour Concentrations

Sampling Month	**Ratio of Modelled to Monitored Odour Concentrations**
Period 1	1.1
Period 2	1.2
Period 3	0.6
Period 4	0.8
Average	0.9

As shown in Table 2B, the ratios of modelled to monitored odour concentrations range from 0.6 to 1.2, with an average of 0.9, indicating slightly under-prediction by AERMOD. This combined analysis is very much in line with the often quoted “factor-of-two” accuracy for AERMOD.

Conclusions

Based on the results of study when two techniques were applied for estimation of the emissions from area sources a portable wind tunnel technique gives values eleven times higher then the emission rates obtained by a flux chamber technique. Other studies performed by ORTECH but not presented in this paper also showed a significant difference when two techniques were applied. The proposed methodology for estimating the odour emission rates from fugitive sources has yielded reasonable convincing results. However, it has to be mentioned that the odour concentrations might vary within the cavity based on our field experience. Therefore, more than one sampling location within the cavity might be necessary to estimate the cavity concentration properly.

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