# Odour assessment methods: appropriate uses to obtain the most accurate results

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This paper presents a brief summary of the different methods for assessing odours and discusses their advantages and disadvantages. Odour assessment methods are divided into two categories: assessments at potential sources and ambient assessments at affected areas, which are usually residential areas located close to potential odour sources. Despite there being several available methodologies, the emphasis is on the following methods: source odour testing with dynamic olfactometry evaluations and dispersion modelling analysis to predict off-site odour concentrations; ambient sampling with dynamic olfactometry analysis, monitoring of ambient odour concentrations using the Nasal Ranger and the Scentroid SM100. In addition to the brief summaries of each available methodology, seven case studies are also introduced to compare their results when different techniques are used.

## 1. Introduction

What is the purpose of odour assessments and why are odour assessments performed? For many facilities, odour can be problematic and may cause complaints from adjacent residential areas. When complaints occur, an investigation may be triggered in the same area, which may eventually lead to an odour assessment which could verify an odour complaint. Odour complaint data can be a very good indicator for odour discharges in the area, but on the other hand, complaint records may not necessarily demonstrate the full adverse effects due to several factors. These factors may include: residents not realizing they may be able to complain, residents tired of complaining and ceasing to do so, and persons not being at their homes when an odour episode occurs. However, odour complaints are very important and useful, especially when they end up being substantiated and are validated.

Odour assessments may also be performed as proactive measures to determine current odour emissions or rank potential odour sources in a facility or area to determine the short or long term odour exposure in residential areas. In addition, when a facility is planning to expand, odour assessments can be performed to estimate expected impacts on the surrounding areas. They can also be performed to determine compliance with odour legislation, to comply with conditions outlined in operating permits and in environmental compliance certificates. It is also important that when a new facility is planned, that background odour be established beforehand with these assessments.

Odour assessments are associated to different types of operations, which may include: any type of industrial operations, wastewater treatment plants, refineries, automotive facilities or landfill/compost operations, as well as any agriculture operations.

Different assessments may be required and will depend on several factors, such as, the type of operation performed, the specific country and the purpose of the

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assessment. Most importantly, the type of assessment can depend on the country, province or state's odour regulations specific to those regions.

There is no standard method for odour assessment but odour assessment can include or be a combination of several approaches. These include:

- Source odour and/or specific compound testing with analysis and dispersion modelling to predict off-site odour concentrations. This is the most common method for assessing odours at the source. This method is introduced later in this paper in greater detail with some case study examples.
- Ambient sampling with odour panel evaluations. This is a very common approach used in Ontario, Canada to assess odours in residential and complaint areas. It is an inexpensive method which will be introduced in greater detail with case study examples.
- Odour monitoring using portable instruments such as the Nasal Ranger or Scentroid SM100. This is a very inexpensive method for measurement and can be used as a screen tool. Results are based on one - person measurement. Both instruments tend to underestimate or overestimate real odour concentrations due to several factors such as: very short measurement time (peak, or no peak), sensitivity of the person involved in monitoring. In the United States (USA) however, the Nasal Ranger is commonly used by inspectors for regulatory purposes. This method is introduced in this paper in detail with some case studies listed.
- Ambient monitoring using grit or plume method. In this method, observations are made by a panellist who performs odour observations for odour intensity following grit or plume methods. The grit method is commonly used in Europe. However, it is a very expensive method and requires a large data base and therefore months of observations. Most data are based on a one-person observation and depend on his or her sensitivity. The data can be very easily different if different persons with different sensitivities towards odour perform this type of assessment
- Continuous odour monitoring using electronic noses- a very expensive method and difficult to use. They are not applicable for all types of sources. Also sensors need to be changed frequently. In addition, a calibration is required before their use.
- Continuous specific compound or a group of compounds monitoring – this can be applied to source monitoring or ambient monitoring. Continuous monitors typically measure concentrations for individual odorants or group of compounds every few seconds and record the data as a one-minute average value. Examples: monitoring systems for hydrogen sulphide and reduced sulphur compounds. Some of these systems are easy to operate but most of them are complex and installation and operation require extensive technical expertise. There are also some limitations such as the detection limits for the instrument - some odours may be detected by a human nose but not detected by an instrument. There are also possibilities that problems may occur with interferences and a false response of the instrument.
- Specific compound sampling followed by specific analysis. For different measured compounds a different collection media is used. Sampling is inexpensive but the analytical cost may be expensive depending on the compound. Limited to detection limits of the analytical instrument used. Some

odours may be detected by the human nose but are below the analytical detection level.

- Community odour surveys: usually performed by screened and trained independent observers downwind from the potential source, namely the facility in question. The number of observers will depend on how large the facility is, the budget for the project, terrain and other factors. Community odour surveys can be an effective alternative or supplement to source testing for odour, particularly in cases where there are a number of potential odour sources that can affect a community, where sources are difficult to sample, or when sources are expected to vary with meteorological conditions. Usually observations are made periodically over an extended time frame. A large data set is required to determine the odour levels at specific locations covering a range of weather conditions. They require a long period of observations; therefore, they can be very expensive. There are some limitations to community odour surveys, such as odour adaption and fatigue. If community odour surveys are performed by community members or from a facility, it may lead to adaptation to particular odours, and would therefore tend to underreport odour occurrence. To avoid this limitation, independent outside observers should be used. In most cases, due to the unavailability or for safety reasons, observations are not performed during early morning or late night hours when odours could be at their worst. Therefore, overall, if performed outside these hours, they may underestimate the actual situation in the affected area.
- Resident observations and questionnaires for residents. A simple logging of odour observations by an individual such as the intensity of the odour, character, duration, and pleasantness. Date and time of the odour episode is usually also recorded, as well as environmental conditions at the time of the odour episode. This method is not expensive and is easy to use; just requires a short training and screening for residents. It may be helpful for initiating an investigation of potential odour or potential odour sources in the area. Limitations: based on the sensitivity of one individual.

## 2. Selected methods for odour assessment

In this section, we introduce in greater detail some of the methods for odour assessments such as odour testing at the sources with olfactometry analysis, ambient sampling with dynamic olfactometry analysis and the use of two available on the market field olfactometers: the Nasal Ranger and Scentroid SM100.

### 2.1 Odour Testing at the Sources, Dynamic Olfactometry Evaluation and Dispersion Modelling Analysis

The general approach for odour testing at the source is to first select the potential source at the facility, then collect odour samples, perform odour analysis using dynamic olfactometry and then use dispersion modelling to predict off-site odour concentrations at sensitive receptors. These predicted-by-model odour concentrations could be verified by actual ambient odour sampling at sensitive receptors on the days of the odour testing at the sources. Several factors should be considered before or during assessments and these include:

- Careful selection of all potential odour sources in the plant including point, area and fugitive sources. All sources should be included in the assessment, otherwise the predicted-by-model odour concentrations may be underestimated when compared to the actual measured ambient odour concentrations.

- Determination of any odour background before any odour testing commences – it is important to determine any other potential sources in the area which may contribute to the off- site odour from the 'facility in question"- otherwise the facility may be blamed for someone else's odour releases.
- Methodology used for the collection of samples from sources. It is especially important for point sources which are humid or/and at high temperature, and also for any area or fugitive sources
- Number of collected samples which should be representative to the actual process of the assessed facility.
- Determine if the process is continuous or batch. In case of a batch process, adequate sampling time should be established.
- Odour analysis techniques.
- Dispersion modelling analysis - type of model used for the estimation of off-site odour concentrations.

There are different methods for odour sampling and they vary by jurisdiction. In Europe, most countries use the methods outlined by VDI 3880 (2011) and/or European Standard EN 13725 (2003). The EN13725 standard is now under revision but was designed more for odour analysis, not sampling. Sampling in Australia and New Zealand follows methods outlined by the Standards Association of Australia (2001) "Stationary Source Emissions. Part 3: Determination of Odour Concentration by Dynamic Olfactometry". Compliance sampling for odour in Ontario, Canada follows the Ministry of Environment and Climate Change (MOECC) Ontario Source Testing Code, Method ON-6" Determination of Odour Emissions from Stationary Sources"[4]).

Different sampling techniques will apply to different types of odour sources. Types of sources:

- Point Source - a single, identifiable source of air pollutant or odorant emissions. Point sources are characterized as being either elevated or at ground-level. Point sources have a defined exhaust diameter. Examples include stacks and vents.
- Area Sources - two-dimensional source of diffuse air pollutant emissions. The dimensions of these sources are either known or can be estimated. Examples include tanks, such as preliminary, aeration tanks at wastewater treatment plants, tailing ponds. See subcategories of the area sources in the text below.
- Fugitive Sources - any open doors, windows, and trucks waiting to unload or load odorous material.

At a point source during testing, odour samples are usually dynamically diluted with nitrogen. For this purpose, a dynamic dilution sampler is usually used to collect samples. After collection of samples at the source, the samples are evaluated for odour detection threshold values (ODTV), which together with volumetric flow rates measured at the source, result in the determination of odour emission rates from the source. For some point sources where expected odour is low, a lung sampling method may be used for collection of the samples. Lung samplers contain a pump which creates a vacuum inside a sealed container (a vacuum chamber) which draws a source sample into the sample bag.

The sampling time depends on the jurisdiction and the nature of the emission source. For example, in Europe a common sample period is 30 minutes for continuous sources. In Ontario, Canada, it is 10 minutes, while in other jurisdictions, a grab sample is common. The sampling time may be adjusted for a batch process. The sampling equipment should be odourless. Storage times between sample collection and evaluation by an odour panel should also be minimized. Criteria for the maximum allowed storage time are outlined in some standard test methods and generally range from six hours (New Jersey) to 30 hours (most European countries, Australia and New Zealand). However, it is expected that some changes for the time will be made with revision of the European EN13725 standard.

When it comes to the estimation of odour emission rates from area or fugitive sources it becomes more complicated. There are some challenges mostly attributed to the difficulty in accurately measuring emissions from these potential odour sources. Area sources are categorized as sources that are open tanks, such as primary or aeration tanks. Within area sources, three different subcategories are determined:

- Active surface sources, *i.e.*, sources that have a noticeable air flow (aeration tanks)
- Passive surface sources: *i.e.*, sources without outward air flow (primary tanks)
- Partially active sources and partially passive sources. These can include complex tanks where the aeration occurs only a few hours a day, which is when the complex tank becomes an active surface source.

Fugitive sources, on the other hand, can be categorized as a truck loading or unloading area, open doors, windows, leaks. Both area and fugitive odour sources are difficult to reliably measure. Therefore, a careful selection of the method is important for a proper assessment.

There are five methods commonly used to predict odour emissions from area sources:

(1) Flux Chamber Method - where nitrogen is used as a sweep gas and a sample is collected at the outlet of the chamber. Usually three samples are collected into a container, which is in most cases a Tedlar bag. These samples are analysed by dynamic olfactometry with a screened panellist to determine the odour concentration. The nitrogen flow rate is used together with the odour concentration to determine the odour emission rate. This method is very frequently used, but the sampling method does not represent the actual conditions on site and therefore tends to underestimate the emission rate.

(2) Portable Wind Tunnel Method – where a portable wind tunnel is used as a replacement of the flux chamber. In this method, the odour samples are taken under different flow rates simulating different wind speeds, which affect odour transfer from a liquid to the gas phase. The odour emission rates are then used for different wind speeds. This approach is much costlier than the flux chamber method due to the instrumentation and set-up procedures, but is more representative of the actual emission rate.

(3) A Back Calculation with an Air Dispersion Model Method - For this method, the ambient odour concentrations are measured at several downwind locations, which are later used in conjunction with a dispersion model to back-calculate odour emission rates. However, that approach requires the collection of a large number of samples at different downwind locations from the area source. Also for this approach, each area source should be separated. In some cases, it is not possible to separate area sources for the specific wind directions.

(4) Static Hood Method - This method is commonly used for active sources such as biofilters and aeration tanks. In this method, a static hood is placed over the

emitting surface. The hood isolates a part of the emitting surface and therefore channels the flow into the hood outlet which is in the shape of a stack. Samples are collected at the port installed on the stack

(5) Mass Transfer Method – Recently, a new method for estimation of the emission rates from the water surfaces was developed which is based on the principle of mass transfer from liquid to gas phase.

For fugitive sources, a back-up calculation method is commonly used for estimation of emissions from these sources.

When estimating fugitive emissions, the following steps are usually required:

Step 1 - Collection of ambient samples within the cavity of the building or structure attached to the fugitive source. Usually more than one sampling location is chosen within the cavity region and at the near wake region. The cavity dimensions are calculated before sampling.

Step 2 - Evaluation of the collected samples using dynamic olfactometry.

Step 3 - Calculations of the cavity concentration. The model is used to calculate the concentration within the cavity. In order to calculate the cavity concentration, the fugitive emission has to be modelled as a point source with certain parameters.

Step 4 - Calculation of the dilution factor

Finally, the odour emission rates are calculated based on the formula

Odour Emission Rate (ou/s) = Dispersion Factor ($m^3$/s) x Ambient Odour Concentration (ou/$m^3$)

In order to predict off-site odour concentrations at selected sensitive receptors, the measured or estimated emission rates are used in the dispersion modelling analysis. Odour models can be classified according to their working principles. The following are categories of models: Gaussian plume models, Gaussian puff models, Lagrangian particle models, Computational Fluid Dynamics models (CFD), In Eulerian models. In Ontario, Canada only two models are approved for regulatory purposes: AERMOD and CAPUFF. In order to run dispersion models for odour assessments, several inputs are necessary such as: emission and source parameters, including nearby buildings, meteorological data. terrain data, and land use characteristics.

Advantages and disadvantages of the source odour sampling method:

- The most common reasonably not expensive method for assessing odour at the sources. If specific compounds are measured at each source, it may be expensive. It may be expensive when CALPUFF model is run.
- Possible ranking of the odour sources which may help in developing methodology for controlling individual odour sources which may contribute the most, therefore in some cases it may be a money savings for the companies struggling with odour issues.
- Easy to monitor emissions for any changes from year to year, which may be beneficial for any changes in the process, expansions.

However, experience in sampling and in designing the source sampling program is essential. The method requires an experienced professional for selecting all potential sources of odour and a careful selection of the methodology for assessing emissions from these sources, especially area or fugitive sources or hot, humid point sources.

The method provides full true odour emissions at each selected source and off site odour impacts when all potential odour sources are included and the right methodology is chosen. Choosing an appropriate procedure for each source is essential, otherwise a significant underestimation of odour emissions may result.

**2.2 Case Study 1- Point Sources: Different Methods Used for Collection of the Samples from Hot, Humid Sources as well as Inlet to the Biofilter**

For each study, at each location or source three odour samples were collected using a dynamic dilution technique and at the same time three samples were also collected using Lung sampler, meaning samples were not diluted with nitrogen on site during the testing.

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 results are presented for hot, humid sources as well as two locations of the Biofilter Inlet.

The odour detection values were determined using dynamic olfactometry and screened panellists according to the European standard EN 13725:2003 and MOECC ON-6 Method.

*Table 1: Summary of the Results.*

| Sampling Description/Location | Odour Detection Threshold Values (OU) | | Factor |
|---|---|---|---|
| | Dynamic Dilution Method | Lung Sampler Method | |
| Hot Source-Location 1 | 34,294 | 2,075 | 16 |
| Hot Source-Location 2 | 1,588 | 124 | 13 |
| Humid Source- Location 1 | 9600 | 1100 | 9 |
| Humid Source-Location 2 | 7200 | 850 | 8 |
| Biofilter Inlet- Location 1 | 13272 | 3090 | 4 |
| Biofilter Inlet- Location 2 | 15400 | 2435 | 6 |

Based on test results, the odour losses at the hot/humid sources were significant, and were recorded by the lung sampler method as thirteen to sixteen times lower for hot sources for the undiluted samples and between 8 to 9 times lower for humid sources for undiluted samples. Also for samples collected at the inlet of the biofilter, the odour losses were significant and were 4 to 6 times lower for undiluted samples with the lung sampler method.

**Conclusion from Case Study 1:** The lung sampling method for collection of samples especially from hot or humid sources underestimates the odour emissions.

**2.3 Case Study 2- Area Sources - Different Methods Used for Estimation of Odour Emissions from Area Sources**

Three different methods were used for estimating odour emissions from area sources located at one of the wastewater treatment plants in Canada. These estimated emissions were used in dispersion modelling to predict off-site odour concentrations at sensitive receptors. The emission rates were established for two different process conditions. These predicted-by-model odour concentrations were compared to actual measured ambient concentrations at three sensitive receptors.

**Method 1** - Flux Chamber Method. At each area source, two sampling locations were chosen for the flux chamber sampling. At each sampling location, three odour samples were collected for odour panel evaluations. Odour emission rates were calculated based on the nitrogen flow rate and geometric mean of odour concentrations from all collected samples.

**Method 2** - Wind Tunnel Method. At the same locations for the area sources, three odour samples were collected for odour panel evaluations. Odour emission rates were calculated based on the air flow rate and the geometric mean of odour concentrations from all collected samples.

**Method 3** - Mass Transfer Method. For this approach, odour samples were collected using the Flux Chamber that acted as a capture hood. It was assumed that the transfer of gases between the water and air was directed by turbulent and molecular transport processes which can be characterized by diffusion coefficients.

*Table 2: Summary of the Results.*

| Location/Condition | Measured Ambient Odour Concentration OU | Predicted Ambient Odour Concentration OU Method 1 Flux Chamber | Predicted Ambient Odour Concentration OU Method 2 Wind Tunnel | Predicted Ambient Odour Concentration OU Method 3 Mass Transfer |
|---|---|---|---|---|
| Sensitive Receptor 1- Condition 1 | 13 | 2 | 12 | 14 |
| Sensitive Receptor 1- Condition 2 | 68 | 7 | 14 | 54 |
| Sensitive Receptor 2- Condition 1 | 10 | 1 | 6 | 14 |
| Sensitive Receptor 2- Condition 2 | 69 | 7 | 43 | 63 |
| Sensitive Receptor 3- Condition 1 | 55 | 5 | 30 | 45 |
| Sensitive Receptor 3- Condition 2 | 138 | 14 | 64 | 73 |

The AERMOD model was used for prediction of off-site odour concentrations at selected sensitive receptors.

In addition to sample collection at the source, several ambient locations were chosen for ambient odour sampling. Samples were collected for different process conditions. At each location, three samples were collected using the Lung Sampler. All ambient samples were evaluated the same way as actual samples collected at the source for odour concentration.

The table below presents the predicted-by-model off-site odour concentrations using three different methods versus measured ambient odour concentrations.

Based on this study, it was found that when a new method for estimating emissions from the area sources (Mass Transfer Method) was used, the predicted-by-model off-site odour concentrations at three sensitive receptors were within the range of measured concentrations or slightly higher than those predicted by the AERMOD

model. The values were within a factor of two, which is a factor commonly used for this model. When the Flux Chamber Method was used, the predicted-by-model off-site odour concentrations were significantly below the measured ambient concentrations.
In addition, the Wind Tunnel Method gave results within the measured ambient levels.
Therefore, when the Flux Chamber Method was used for sampling, the odour emissions were significantly lower compared to Mass Transfer Method or Wind Tunnel Method.
**Conclusions from Case Study 2** In conclusion, it is very important to consider the right methodology to be used for the estimation of the odour emission rates from any area or fugitive sources.

### 2.4 Case Study 3 - Fugitive Sources- Back Up Calculation Method to Estimate Fugitive Odour Emissions

The study was performed at a Waste Facility where two main areas were considered as potential odour sources. At each area, the odour emissions were discharged from either the exhaust stacks located on the roof when the exhaust fans were turned on or from the receiving doors when the exhaust fans were turned off and the doors were open. Theoretically, the emission rates from either the exhaust stacks or receiving doors should be the same. For the condition when the exhaust fans were turned on, samples were collected at the stacks (fan on), and a procedure for the collection of samples from point sources was applied. The geometric mean of odour detection threshold values from the three samples collected was multiplied by the measured volumetric flowrate to determine the odour emission rates. This was done separately for the two areas.
The second condition was when the exhaust fans were turned off, therefore it was estimated that the odour emissions came from the receiving doors only. For this scenario, in order to estimate the sampling location from the doors, before even sampling started, a cavity of the region was calculated based on building dimensions. Two sampling locations were chosen within the cavity and three samples were taken concurrently at approximately 1.8 m above the ground. Based on the analysis in the laboratory using a dynamic olfactometer, an ambient odour concentration within the cavity was calculated. Later on the model was used to back-up calculate the odour emission rates from these receiving doors. Table 3 present the results for the study.
Based on this study, the odour emission rates estimated using back-up calculation are very much in line with those estimated using a conventional method for estimating odour from point sources.
**Conclusions from Case Study 3** The methodology used for assessing emissions from fugitive sources was accurate.

*Table 3: Comparison of Odour Emission Rates Estimated Using Two Methods.*

| Process | Odour Emission Rate ou/s ($m^3$ basis) | Ratio Odour Emission Rates Stacks to that Estimated from Doors |
|---|---|---|
| Area 1- Stack- Fan On | 175060 | 1.1 |
| Area 1- Fugitive- Doors | 158450 | |
| Area 2-Stack- Fan On | 949412 | 0.98 |
| Area 2- Fugitive- Doors | 964190 | |

### 2.5 Case Study 4

This study was based on odour assessments at an Organic Waste Facility in Canada. At this facility, samples were collected at point sources (stacks) as well as at three main fugitive sources which were the open doors at the receiving area, trucks waiting to unload and an opening at a material storage. The odour emissions from stacks were estimated using a conventional extractive method. Odour emissions from fugitive sources were estimated using the Back-Up Method. All collected samples were evaluated using dynamic olfactometry.

In addition to sampling inside the facility, ambient odour samples were collected at the most impacted sensitive receptors. A dispersion model (AERMOD) was used to predict off- site odour concentrations for ambient measurement sensitive receptors.

This facility was assessed during different seasons.

All predicted off-site concentrations and measured off-site were compared during different seasons.

The paired comparison of the modelled and monitored odour concentrations is tabulated in Table 4.

*Table 4: Summary of the Results - Measured Odour Concentrations Versus Predicted.*

| Sampling Season | Measured Ambient Odour Concentration OU | Predicted by Model Odour Concentration OU |
|---|---|---|
| Season 1 | 24 | 22 |
| Season 2 | 37 | 31 |
| Season 3 | 11 | 18 |
| Season 4 | 23 | 29 |

As shown in Table 4, in two seasons, (Season 1, Season 2) the AERMOD model slightly under-predicted odour concentrations when estimated fugitive odour emission rates were plotted into the model. Overall, the combined analyses are very much in line with the often quoted “factor-of-two” accuracy for AERMOD.

**Conclusions from Case Study 4** Estimation of the fugitive odours from receiving doors, storage area and trucks was very close to the actual odour emissions, therefore the back-up method used for the estimation of fugitive odour sources was very accurate.

### 2.6 Ambient Odour Assessments using Ambient Sampling and Dynamic Olfactometry Analysis

When it comes to ambient odour assessments there are different techniques and they may vary from jurisdiction to jurisdiction. In Ontario, Canada, the most popular method for assessing ambient odour is ambient odour testing and dynamic olfactometry analysis.

Ambient sampling for odour assessment is typically conducted using the lung sampling technique with the sample collection done in ambient air rather than within a source such as a stack.

This method is one of the most common methods to assess ambient odour, provided the odour concentration is sufficient to give panelist responses at the lowest dilution levels of the olfactometer. If the odour concentration is too low for a sample to be

evaluated by olfactometry, then the odour panelists can evaluate the sample directly from the sample bag.
The lung sampling procedures for ambient odour monitoring are similar to sampling at the sources using the lung method with exception that the sampling probe is located about 1.5 m above ground level but specific heights may be selected based on the nature of the monitoring program. Sampling periods depend on the jurisdiction (e.g., 10 minutes in Ontario) but can vary depending on the nature of the upwind source and the meteorology.

**2.7 Case Study 5 - Measured Odour Emissions and Dispersion Modelling Analysis versus Ambient Sampling and Olfactometry Analysis**
In this study, the odour emissions were measured and used in the dispersion modelling analysis to predict off-site odour concentrations. At the same time, a lung sampler was used for ambient assessments of odours at sensitive receptors, downwind from the tested facility. Three samples were collected at each source as well as three samples at the sensitive receptors. In addition, an upwind location was selected and tested for any background odour. The results for ambient odour concentrations are taken as geometric mean from three collected samples at that location.
Table 5 presents the results.

*Table 5: Summary of the Results - Measured Odour Concentrations Versus Predicted by the AERMOD Model.*

| Location | Predicted by AERMOD Model Off- Site Odour Concentration OU | Measured Ambient Odour Concentration OU |
|---|---|---|
| Sensitive Receptor 1 | 41 | 80 |
| Sensitive Receptor 2 | 46 | 72 |
| Sensitive Receptor 3 | 15 | 18 |
| Sensitive Receptor 4 | 82 | 126 |

Based on these results, the predicted by-model off-site odour concentrations are slightly lower than measured. However, they are in line with the model error of factor 2.

**2.8 Ambient Odour Monitoring Using Field Olfactometers**
A field olfactometer such as the Nasal Ranger or Scentroid SM100 directly determines the odour concentration in the ambient air without the requirement to collect a sample in a container.
The field olfactometer, which is used by one person at a time, draws ambient air into the instrument. The diluted sample is presented to the odour observer via a face mask and the observer indicates whether an odour can be detected at each dilution. The results from the Nasal Ranger are used to calculate the detection to threshold (D/T) which is the number of dilutions needed to make the odour ambient air non detectable.
All field olfactometers (Nasal Ranger and SM100) are based on individual one person readings for one-minute maximums whereas ambient sampling for laboratory olfactometry generally occurs for a longer time. Due to this short time frame, accurate results cannot be guaranteed, therefore it should be considered a screening tool only, because the method is expected to be less accurate than any other method and mainly depends on the sensitivity of the person performing readings at a short time. As one observer operates the instrument, results depend on operator sensitivity. In addition,

the observer likely breathes odorant before using the field olfactometer, increasing the opportunity for odour fatigue.

Limitations of the field olfactometers include:

- Provide peak instantaneous odours, whereas ambient sampling provides odour concentrations averaged (10 minutes, 30 minutes.)
- Readings can easily accommodate needs and can be performed only when odours are detected and at their peak. Whereas the odour sampling time averages from 10 minutes to 30 minutes.
- Use of masks require the use to alter their breathing process and pattern, which may affect results. Typically results tend to be lower.
- Readings are based on one - person sensitivity which can highly vary from person to person.
- Fatigue can occur and quite quickly with the person performing the readings.
- Not capable to perform any readings over a long period of time.
- Data are based on the day and the time of the readings and do not cover all hours or meteorological conditions.

In addition, the Nasal Ranger has attached carbon filters which may not be capable of filtering some odorants sufficiently (Bokowa 2008.) On the other hand, Scentroid SM100 uses separate air tanks which are filtered, but the tanks have only a sufficient volume of clean air which only lasts for 30 minutes at a time, and which may not be sufficient enough to perform ambient readings without any interruption.

### 2.9 Case Study 6 - Odour Concentrations Obtained by Ambient Sampling and Dynamic Olfactometry Analysis versus Nasal Ranger Readings

This study is based on the results obtained by two methods: the Nasal Ranger and ambient sampling with dynamic olfactometry analysis. At each location, Nasal Ranger readings were taken to determine the detection to threshold (D/T). At the same location, three odour samples were taken for odour evaluations. Table 6 presents the results.

As shown in Table 6, the results obtained with using the collection of bag samples with evaluation by dynamic olfactometry and screened panellists are by a factor of two or more higher than the results obtained with the Nasal Ranger instrument.

**Conclusion from Case Study 6** It was expected that the Nasal Ranger measurements would be higher due to the possibility of catching odour peaks over a shorter period of time. However, the Nasal Ranger data are much lower than data obtained by ambient sampling.

*Table 6: Comparison of Ambient Odour Levels Using Ambient Sampling versus Nasal Ranger Readings.*

| Location | Odour Concentration using Ambient Sampling OU | Nasal Ranger D/T |
|---|---|---|
| Location 1 | 9 | 2 |
| Location 2 | 16 | 2 |
| Location 3 | 12 | 4 |
| Location 4 | 29 | 15 |
| Location 5 | 91 | 30 |

**2.10 Case Study 7 - Odour Concentrations Obtained by Ambient Sampling and Dynamic Olfactometry Analysis versus Scentroid SM100 Monitoring**

Several studies were performed involving the SM100 unit. The first study (Bokowa, 2012) compared odour concentrations in the collected bags obtained by evaluation of the sample using dynamic olfactometry and eight panellists to readings obtained by the SM100 with attached port, not a mask, as designed by the manufacturer. All of the studies presented in that paper were studies when the samples were already collected and dynamic olfactometry was applied. In addition, the readings were taken in the bag using the SM100. In real conditions the SM100 is designed to be used on site, not on collected samples, and secondly with attached mask, not a port, as studied in 2012. Therefore, caution should be applied when interpreting studies from 2012. Table 7 below shows some of the results from 2012.

*Table 7: Comparison of Odour Concentrations in Collected Bags Using the Dynamic Olfactometry and SM100 with Attached Port.*

| Description | ODTV SM100 (using port) OU | ODTV using Odour Panel OU |
|---|---|---|
| Sample 1 | 94 | 116 |
| Sample 2 | 164 | 108 |
| Sample 3 | 721 | 515 |
| Sample 4 | 164 | 201 |
| Sample 5 | 3750 | 2363 |
| Sample 6 | 3000 | 1955 |
| Sample 7 | 3330 | 2048 |

Based on these results, the odour detection threshold values obtained by the SM100 with attached port for samples collected at the sources which were high in odour (above 1900 OU) were much higher than obtained by standard dynamic olfactometry analysis with a variation of results between 24% to 38%. For other samples (lower than 1900) the SM100 readings were in line with dynamic olfactometry results but with the variation that some of the results were higher and some lower than the ODTV obtained by dynamic olfactometry. All studies were performed in the laboratory, not on site and SM100 readings were performed with attached port, not mask. Therefore, all presented data cannot be used to compare these two methodologies for assessing ambient odour.

The second study was performed on-site during the collection of samples. All collected samples for ambient sampling were evaluated by eight panellists using dynamic olfactometry. At the same time SM100 readings were performed on site. One reading was performed using SM100 with attached port and the second reading with attached mask. Table 8 summarizes the results.

As shown in Table 8, the results obtained by using the collection of bag samples with evaluation by dynamic olfactometry and screened panellists are either higher or lower than the results obtained with the SM100 instrument when ports are attached which may indicate that SM100 might catch a peak or not during short readings (1 minute) versus 10-minute sampling time using a Lung sampler. When the mask is attached, the

SM100 results are much lower than obtained when the port was attached. However, the ports cannot be used during ambient monitoring due to the interference with readings. Therefore they can be used only in the laboratory.

*Table 8: Comparison of Odour Concentrations Using Dynamic Olfactometry and SM100 with Attached Mask*

| Description | Odour Concentration using Ambient Sampling OU | Scentroid SM100 Using Ports OU | Scentroid SM100 Using Mask OU |
|---|---|---|---|
| Location 1 | 450 | 319 | 164 |
| Location 2 | 255 | 328 | 94 |
| Location 3 | 32 | 55 | 22 |
| Location 4 | 44 | 55 | 24 |
| Location 5 | 81 | 109 | 62 |

## 3. Conclusions

There are different methods for assessing odours, however they will depend on several factors. A careful selection of the methodology used should be considered before any assessments are performed. Considerations should be made that involve assessing the location of the jurisdiction, the appropriate standards needed to be met, the amount of time available for assessment, whether it be days, months or years, and the financial budgets allowed for the project. Careful thought should be placed on appropriate methods also relating to the type of sources tested (point, fugitive and area sources) and the difficulties in being able to assess them. Lastly, any investigation should attempt to yield the most accurate results and therefore a variety of assessment methods can and should be used, so that underestimation does not occur.

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