CHEMICAL ENGINEERING TRANSACTIONS Volume 23, 2010
Editor Renato Del Rosso
 ISBN 978-88-95608-14-3 ISSN 1974-9791
DOI: 10.3303/CET1023015

Ambient Measurements as Verification of Models for Prediction off-site Odours

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

When it comes to assessing off-site odours from a facility, the use of a dispersion model is almost always mandatory. There are several models used for odour and there is always a dilemma of which model is better. However, each model has different limitations and errors and various other factors contributing to the final results, therefore it is almost unknown if predicted by model off- site odour concentrations are true values or if they are close to the real values.
This paper introduces the technique for verification of odour predictions by dispersion modelling. Simply, ambient sampling on the days of source sampling performed at the sensitive receptors verifies if the model was right. However, some precautions should be followed.
This paper is based on several studies performed in Ontario, Canada when ambient sampling was performed at the same time as source sampling and different models were used to predict off-site odour. The correlation between measured and predicted values is presented in this paper.

Introduction

Odour is considered as nuisance, there is a question on how to demonstrate a nuisance. A nuisance can be demonstrated by odour assessments/testing programs. During the programs, the potential odour sources in the plant are assessed for odour emissions. Odour samples are usually collected at the potential odour sources- either point, area, or fugitive sources and the combination of data from the evaluation of the sample bags are used with the measured flow rate at the source to determine the emission rates from each source. Different techniques are used for collection of the samples such as dynamic dilution technique for collection of samples from point sources or a wind tunnel for the collection of samples from area sources. Later on the odour emission rates are used in the dispersion modelling calculation in order to predict off-site odour concentrations. However there is a question, if the predicted by model off-site odour concentrations are actual concentrations., then how do we know if the model predicted correctly? How do we know if the methodology used for the collection of the samples or analysis was the correct one?

Please cite this article as: Bokowa A.H. and Bokowa A.H., (2010), Ambient measurements as verification of models for prediction off-site odours, Chemical Engineering Transactions, 23, 87-92
DOI: 10.3303/CET1023015

Actual ambient sampling downwind from the potential source (facility) during the source sampling is the best tool for determining if the model predicted correctly.
ORTECH performed several studies including sampling at point, area and fugitive sources and at the same time ambient measurements were taken downwind from the assessed facility. The measured odour emission rates at the source were used in the dispersion modelling calculations to predict off site odour concentrations and these values were compared with actual ambient measurements. The correlation between the prediction of the model and the actual measurements are introduced in this paper.

Methodology

Study 1

This study is based on the full odour assessment at one facility located in Ontario, Canada. Several complaints were reported to the Ontario Ministry of the Environment. A full odour assessment was scheduled for that facility including sampling at point and fugitive sources. There were several fugitive sources at the plant. The odour emission rates from each point and fugitive source at the plant were determined and their off-site odour contribution at specific sensitive receptors was also determined. Two models were used to predict off-site odour concentrations, the AERMOD model and the CALPUFF model.
The latest version of the AERMOD dispersion model (Version 07026) was used to predict the maximum 10-minute average odour concentrations at seven selected sensitive receptors. A 5-year meteorological data set was used for the modelling. Also a CALPUFF model was used to predict off-site odour concentrations for calm conditions.
In order to verify the predicted by model odour concentrations, two days of ambient sampling was scheduled during the program. On July 22, 2008 and July 24, 2008 ambient odour sampling was performed at four downwind locations.
Two models, AERMOD and CALPUFF were run twice. Once with five years meteorological data and the second time for the day of ambient sampling using recorded meteorological data for the date and hour of ambient sampling. The predicted odour concentrations were compared with measured off-site odour concentrations. It was found that the measured odour concentrations at four locations on two different days were reasonably close to those predicted by AERMOD model off-site odour concentrations. CALPUFF overestimated the off-site odour concentration; however, the values were within a factor of two.
The following tables summarize the source odour emissions and the maximum predicted sensitive receptor odour levels based on two models.

Sampling Location	Measured Odour Concentration (ou)	Odour Concentration Predicted by AERMOD Model (ou)	Odour Concentration Predicted by CALPUFF Model (ou)
July 22, 2008			
Location A	80	41	117
Location B	72	46	133
July 24, 2008			
Location C	170	83	82 (occurs between locations C and D)
Location D	126	82	

As indicated in the Table above, the predicted by AERMOD model values are within the range of the measured values. The CALPUFF overestimated the off-site odour concentration; however, the values are generally within a factor of 2 of the measured concentrations. It gives some confidence in the estimated odour emission rates especially for the fugitive sources.
For the modelling using 2004 full year meteorological data, the 10-minute odour concentrations predicted by CALPUFF are much smaller than those predicted by AERMOD.

The differences could be mainly attributable to the following factors:

- The building downwash algorithms (CALPUFF used the ISC-type building downwash algorithm while AERMOD used the PRIME algorithm);
- The mixing heights (CALPUFF limited the lowest mixing heights to 50 m while AERMOD had no limit on the mixing heights. The majority of the higher odour concentrations predicted by AERMOD occurred with mixing heights below 50 m)
- Meteorological conditions (CALPUFF used 3-D meteorological data produced by CALMET while AERMOD used the surface hourly meteorological data at London Int'l Airport, Ontario, and upper air data at White Lake, Michigan)
- Due to the MOE's processing routine for the calm/missing conditions (http://www.ene.gov.on.ca/envision/air/regulations/metdata/README_V2.pdf), no real calm condition (i.e., both wind speed and direction set to zero) was present in the surface files provided by the MOE. This routine might have compromised our purpose, i.e., using the CALPUFF to capture the odour episodes under light and calm conditions.

Study 2
This study is based on the odour assessments at an Organic Waste Facility. This facility has biofilters installed to control emissions from most of the areas in the plant. However, there are some fugitive sources such as opening doors from the receiving area or even trucks waiting to unload which accounted as fugitive sources. The odour emissions from biofilters are discharged through stacks, and were estimated using the conventional extractive method. Odour emissions from other fugitive sources were estimated using the methodology developed by ORTECH and introduced in the paper "Quantification of Odour Emissions from Fugitive Sources" A. Bokowa, H.Liu (2)

There are several fugitive sources in the plant such as receiving doors, opening of the storage material, waste transport trucks, these sources are dominant odour sources at the plant. Before assessing fugitive sources, a cavity of the region was established based on the structure dimensions and that helped to establish the sampling locations downwind from the structure. For the receiving door, three samples were taken at one location at 1.8 m above ground again within the cavity. For the opening of storage of the material, three locations were chosen and three samples were taken at each location at 1.8 m above ground within the cavity. For waste transport trucks, two trucks loaded with different waste materials were parked perpendicular to the prevailing wind directions. For each type of truck the cavity was calculated and within that cavity three sampling locations were chosen and at each location three samples were collected at the same time. Also, one upwind location was chosen in order to establish the background odour. In addition to sampling inside the facility, ambient odour samples were collected at the most impacted sensitive receptors.
This facility was assessed during four different episodes representing different months. During each episode, ambient samples were taken during different times during the day just to cover different meteorological conditions and emission profiles. All the ambient odour samples were collected at 1.5 m above ground and were evaluated using dynamic olfactometry to obtain off-site odour concentration.
All predicted off-site concentrations and measured off-site concentrations were compared during different episodes. The paired comparison of the modelled and monitored odour concentrations is tabulated in Table 2.

Table 2 Ratio of Predicted by Model to Measured on Site Odour Concentrations

Sampling Episode	Ratio of Predicted to Measured Odour Concentrations
Episode 1	1.1
Episode 2	1.2
Episode 3	0.6
Episode 4	0.8
Average	0.9

As shown in Table 2, the ratios of predicted by model to measured odour concentrations range from 0.6 to 1.2, with an average of 0.9, indicating a slight under-prediction by the AERMOD model when estimated fugitive odour emission rates were plotted into the model. This combined analysis is very much in line with the often quoted “factor-of-two” accuracy for AERMOD, therefore it was assumed that the estimation of the fugitive odours from receiving doors, storage area and trucks were very close to the actual odour emissions. Therefore, the methodology used for the estimation of the fugitive odour sources was very accurate.

Study 3

The odour testing program was performed at a facility located in Barbados. All significant odour sources inside the facility were tested including point sources and fugitive sources. In addition to source sampling ambient sampling was also scheduled during the days of testing at the sources. Two sampling locations were chosen for the ambient sampling downwind from the facility.
During each day at each location, three samples were collected using the lung technique. One upwind location was chosen during each ambient sampling episode, three samples were collected and analyzed for any background odour.
The latest version of the AERMOD dispersion model (Version 07026) was used to predict maximum 10-minute average odour concentrations at selected sensitive receptors. A 5-year meteorological data set (2003-2007) was used for the modelling.
The comparison of the measured ambient odour concentrations and the modeled odour concentrations for all occasions is shown in the table below and indicated a very good correlation between the predicted values and measured values.

Comparison of Measured and Modeled Odour Concentrations

Sampling Location	Ambient Odour Sampling Measured	Modeled Odour Concentration
Location A	19	15
Location B	<1	<1

Conclusions

As shown in this paper ambient sampling is a very good tool for verification of the prediction of off site odour concentrations. However some limitations apply such as choosing the right model, and the error of model itself. It is very important that during the assessment at a facility all sources are included in the assessment such as fugitive sources, which are difficult to assess, however with a new technique it is possible to include them.
The ratios of predicted by model to measured odour concentrations range from 0.6 to 2 which is still within the model error. Even with the fact that estimated fugitive odour emission rates were plotted into the model. This combined analysis is very much in line with the often quoted “factor-of-two” accuracy for the AERMOD or CALPUFF model, which was established by the USEPA after extensive studies.

References

A. Bokowa, “Ambient Odour Assessments: Comparison of Two Techniques Used for Ambient Odours”, 3rd IWA Conference, Barcelona, Spain, October 2008

A. Bokowa, H. Liu, “Quantification of Odour Emissions from Fugitive Sources”, 3rd IWA Conference, Barcelona, Spain, October 2008

A. Bokowa; “Methods for Sampling of Odours, AWMA Symposium on Air Quality

Measurements Methods and Technology, San Francisco, May 2007

The Ministry of the Environment's Draft Source Sampling for Odours, Version #2, February 1989.

Environmental Protection Agency Office of Environmental Enforcement (OEE) " Air Dispersion Modelling from Industrial Installations Guidance Note (AG4)

R. Schulze; " Improving the Accuracy of Dispersion Models"