

Correlation between odour concentration and odour intensity from exposure to environmental odour

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Abstract. The encroachment of industries, agricultural activities and husbandries to the community area had been a major concern of late, especially in regards to the escalating reports of odour nuisances. A study was performed with the objective of establishing correlation between odour concentration and odour intensity, as an improved method to determine odour nuisances in the community. Universiti Sains Malaysia Engineering Campus was chosen as the study location, due to its vicinity to several odour sources including paper mill, palm oil mill and poultry farm. The odour survey was based on VDI 3940, to determine the level of odour intensity with the corresponding odour concentration measured using an infield olfactometer. The correlation between both methods shows a significant correlation by using Pearson Correlation with a level of confidence of 99.9 percent. The graph plotted between intensity and concentration shows the R^2 value of 0.40 which indicated a good correlation between both methods, despite having a high variance and low in consistency. Therefore, this study concludes that the determination of odour concentration should be complemented with odour intensity in order to recognize the true impact of odour nuisance in a community.

1. Introduction

The growth of industrial facilities around the community area had been a major concern for the residential area. One of the problem that had been a topic of major concern is odour problem. It had been several decades, that the odour episodes resulting directly or indirectly affects human activities and have caused adverse effects on the citizens (Aatamila et al, 2011) and are recently being considered as atmospheric contaminants. One of the major population's complaint to local authorities was caused by the odours problem (Henshaw et al., 2016), hence odours should be acknowledge as one of the atmospheric pollutants. However, not all pollutants are perceived, there are some conventional pollutants that are generally not perceived by population, even if they might be harmful to human health, especially if normal exposure limit concentration are exceeded. In contrast, some odour are perceived far below normal exposure limit concentrations, this might be caused by the presence of odourous compounds having extremely low odour detection threshold concentration. For these reason, control and regulation had been reinforced in many countries (Nicell, 2009). There were many types of method and techniques in measuring the odour had been done in research and studies.



VDI 3940 is a standard series describing the methodology for assessing the odour of ambient air around the selected source in a grid or in a plume pattern. There are a few countries that adopted this method for assessing odour nuisance such as Germany, Austria, France and Netherland (Sowka, 2010). This method consist of two measurement which are grid measurement and plume measurement. According to the standard part one of a VDI 3940 series, a grid measurement is a technique in which a team of assessor register odours in following measurement grid within the area under study for a fixed period of time. The results obtained are used for assessing the impact of odours on air quality (Sowka, 2010). Research area is recommended to be covered uniformly with spaced grid points. Measuring squares are created by connecting 4 points. The grid is very important step for a proper evaluation of odour impact. The step set up initially recommended to be equal to 250m. Depending on the conditions and needs, higher (up to 500m) or lower (e.g 125 m, 100 m and 50 m) steps are also acceptable. Whereas, according to VDI part 2, a plume measurement is carried out in order to obtain information on the impact of odour in a single measurement variable for the calculation impact. In contrast with the grid measurement, plume measurement is related to a specific industrial facility. Odour from the emitter permeates the air and this process is directly dependent wind speed and direction and atmospheric stability. Assessor move away from the plant downwind to the end of a plume. A minimum of three intersection is required according to the VDI standard. At least five measurement points for an intersection line crosses and is plotted by five assessors.

Portable olfactometer is an in-field measurement equipment that had been used to measure the odour. There are a few type of portable olfactometer such as Nasal Ranger, Scentroid SM100 and Scentroid SM110. This portable olfactometer is a portable device which come with a source of clean filtered air and a dilution system based on a several calibrated orifice (Benzo, Mantovani & Pittarello, 2012). The dilution of the external air can be reduced gradually until odour is perceived and the dilution to threshold (D/T) value is obtained according to ASTM E679-04 (2011). According to IDES Canada Inc., (2012) Scentroid Sm110 Field Olfactometer using the same basic theory of lab based olfactometer which allows accurate quantification of ambient odour strength. This equipment draws a sample of ambient a air via venturi vacuum pump and dilutes it using carbon filtered air from a high pressure compressed air tank. The mixed air will flowed to the face mask attached and the dilution ratio of clean air to sample is controlled via the designated flow regular valve. The operator can slowly increase the concentration of the mix until the odour of ambient air is detected. The operator may select between 15 dilution ratios when measuring odour concentration in ambient air.

2. Methodology

2.1 Location of study

Figure 2.1 shows the point that had been marked and where all the assessors had been placed during the assessments, within the Engineering Campus, Universiti Sains Malaysia. Different colour of the pointer shows that the different date of assessment. Blue pointers represent date on 3rd April 2015, pink was 8th April 2015, turquoise was on 15th April 2015 and the purple pointer was on 17th April 2015.

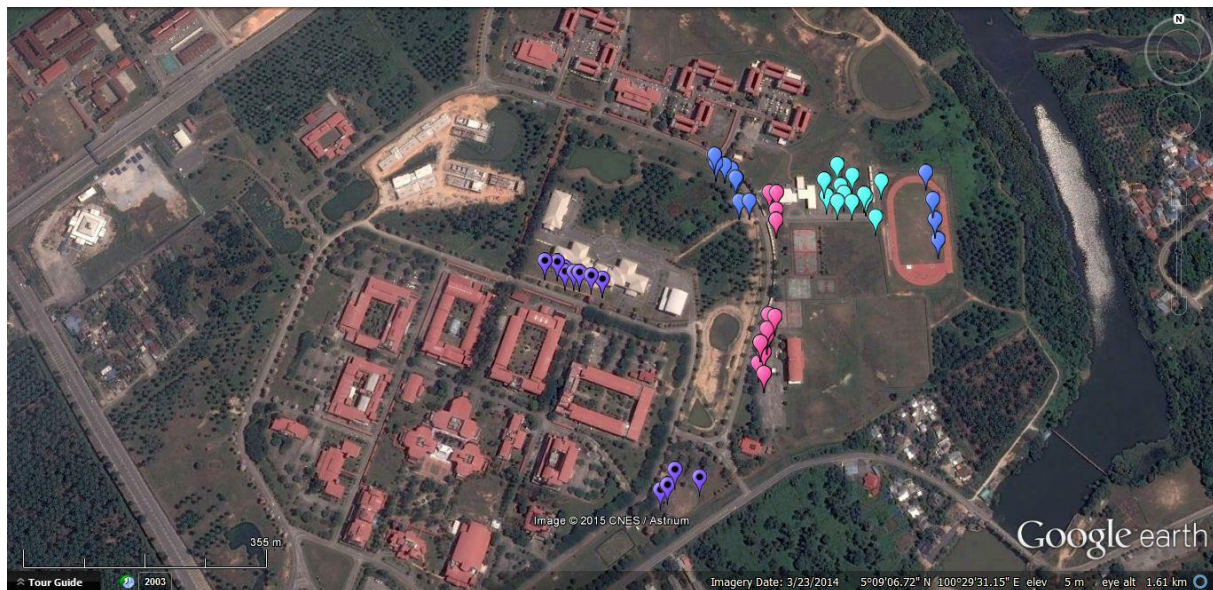


Figure 2.1 All points of assessment

2.2 Odour assessor training

All the assessors need to take the odour test before they are qualified to be the assessors. The odour test was carried out by using Peptone solution. Five Peptone solution were prepared with different scales of odour. The different concentration gave different intensity of odour. The higher the concentration, the stronger the odour. The assessors need to arrange all the solution according to their intensity whether from the highest concentration to the lowest concentration or vice-versa. The assessors will pass the test if their answers are 80 percent correct. Total assessors for each odour survey was 4 people. All assessor chosen had carried out a training on 25th March 2015. On the training day, all assessors have learned how to conduct the odour survey

2.3 Determination of odour intensity

By following the required standard VDI 3940 Part 2, all the assessors were given a stopwatch so that the data were taken simultaneously on site. The assessment sheet was given to each assessors. The operator will set the point and put each of the assessor at the point that had been decided before the assessment.

When all the assessors were ready at the chosen point, the operator will blow the whistle which mean they can the start assessment at the same time. All the assessor noted down the odour level that they perceived every 10 seconds on their assessment sheet. Table 2 shows the choice of the level of the odour. The assessors also need to note down the characteristic of the odour they perceived. For example, the odour characteristic can be grassy, smoky, POME or others. The assessment consists of 10 minutes a cycle. One complete assessment consist of 3 cycle. Therefore, for 4 assessors the total data for every one complete assessment is 720.

Table 2 Intensity scale and the description

Intensity Scale	Description
0	No odour
1	Very weak
2	Weak
3	Distinct
4	Strong
5	Very strong

2.4 Determination of odour concentration

Portable olfactometer was used as the second method to assess the odour impact at the community. The portable that had been used in the assessment is Scentroid SM100. Same as the odour survey, the operator of the SM100 also have to take the odour test. Total operator of SM100 is 2 persons. However, at least one have to be present for the infield assessment. Another operator is for the backup. The operator will be given a stopwatch and a form sheet to record the data. The portable olfactometer operator will start at the assessment at the same time as the odour survey assessors. The assessment was done at the same time so that both of the data can be compared. The operator will note down the result every 2 minutes in a cycle of 10 minutes. Same as the odour survey, one complete assessment consists of 3 cycle.

The portable olfactometer follows the Air Quality Standards and Air Pollution Control Rules, Missouri, USA. The operator needs to write down the time of the odour perceived and the value scale. The use of MS1963:2007, dynamic olfactometer for the purpose of ambient odour monitoring is not promoted due to the complexity and the insensitivity of the odour. As mentioned by DEFRA dynamic olfactometry cannot be used for ambient monitoring, which is why it is more suitable to use portable olfactometer.



Figure 2.2 Operator of the SM100

3. Results and Discussion

The result from the all assessment around the location of study were corresponding to odour intensity. The field odour surveys indicate the presence of odour which were recognizable and at times may be quite strong. The highest percentage is level 1 with 18 percent followed by level 2 with 3 percent while level 3 and 4 were quite low with only 0.5 percent and 0.03 percent respectively.

Table 3.1 Percentage of odour intensity in all assessments

Odour Intensity	Description	Percentage Odour Intensity (%)
0	No odour	78.72
1	Very weak	17.95
2	Weak	2.74
3	Distinct	0.56
4	Strong	0.03
5	Very strong	0
Summation of all odours perceived from all assessments		100

By only considering identifiable odour that had been recorded by the assessors, the result shows that the highest percentage of the odour type was Palm Oil Mill Effluent (POME) with 74.9 percent, followed by poultry (15.5 percent, smokey smell (8 percent) and others. POME was recorded as the highest odour perceived might be caused by a palm oil mill located 0.75 km from the site of study. This can be concluded that, it was the main source of the odour problem (Department of Environment and Conservation, 2008).

The highest concentration recorded was 60 OU/m³. This result was recorded on the 15th April and the location of the assessment was located near palm oil mill. One of the previous studies did an assessment with the location of the downwind was a pet food. The highest result of the studies was 59 OU/m³, which was relatively near to this studies result.

By using the Pearson correlation, the analysis of the relationship between odour intensity and concentration was determined. As shown in Table 3.2 below, the correlation is significant at 0.01. From this analysis, it can be concluded that odour intensity do correlate with concentration. This may be due to the trend of the result which showed that, when the odour intensity increased, the concentration also increased. Meanwhile, Figure 3 shows the comparison between intensity and concentration. By plotting the graph, the R² that obtained is 0.40. This shows that the variance from both of the result is high, thus the consistency from the intensity and concentration is low. Naddeo et al., (2013) stated that odour that was perceived by human nose may not be corresponding to the changes of odour concentration. However, these two subject do have a correlation.

Table 3.2 Correlation between odour concentration and odour intensity

Correlations			
		Concentration	Intensity
Concentration	Pearson Correlation	1	0.674**
	Sig.(2-tailed)		0.000
	N	55	55
** Correlation is significant at the 0.01 level (2-tailed)			

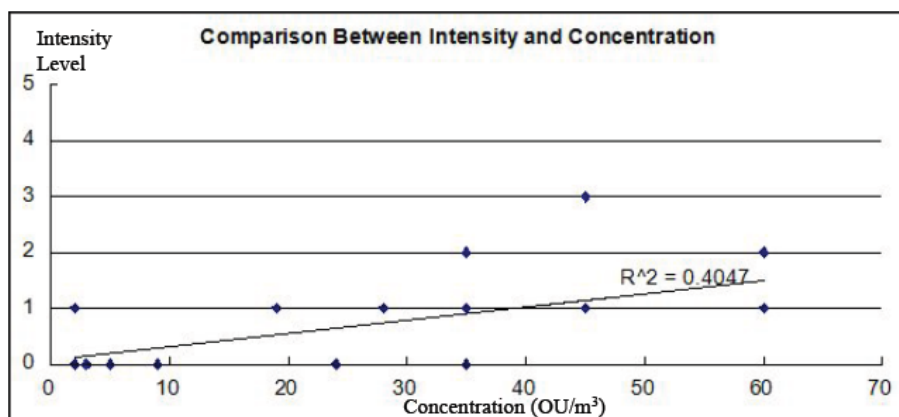


Figure 3 Comparison between Odour Intensity and Concentration

4. Conclusion

The findings of this study indicated that intensity and concentration do have a significant correlation. However, there were occasions that high intensity occurred at low odour concentration. The changes in concentration did not always produce a corresponding proportional change in the odour intensity as perceived by the human nose. This is why the comparison between intensity and concentration resulted in the 0.40 R^2 . This shows that, even at low concentration, high intensity may occur and cause annoyance to the receptor.

References

- [1] Aatamila, M., Verkasalo, P., Korhonen, M., Suominen, A., Hirvonen, M., Viluksela, M. and Nevalainen, A. (2011). Odour annoyance and physical symptoms among residents living near waste treatment centres. *Environmental Research*, 111, pp.164-170.
- [2] ASTM International (2011). E679-04: *Standard Practice for Determination of Odor and Taste Threshold by a Forced-Choice Ascending Concentration Series Method of Limits*. Philadelphia, PA, USA.
- [3] Benzo, M., Mantovani, A. and Pittarello, A. (2012). Measurement of Odour Concentration of Immissions using a New Field Olfactometer and Markers' *Chemical Analysis*, vol 30.
- [4] Department of Environment and Conservation, (2008). Odour Investigations around the Southern Metropolitan Regional Council's Regional Resource Recovery Centre in Canning Vale.
- [5] Department for Environment, Food and Rural Affairs (DEFRA). (2010). Odour Guidance for Local Authorities: Odour Assessment technique, pp 31-43.
- [6] Henshaw, P., Nicell, J. and Sikdar, A. (2006). Parameters for the assessment of odour impacts on communities. *Atmospheric Environment*, 40(6), pp.1016-1029.
- [7] IDES, Canada Inc. (2012) Scentroid SM100: In-Field Odour Measurement. IDES CANADA INC. Available: www.scentroid.com, [29 March2015]
- [8] MS1963:2007, (2007). Air Quality - Determination of odour Concentration by Dynamic Olfactometer. Department of Standard Malaysia, Selangor, Malaysia.
- [9] Naddeo, V., Belgiorio, V. and Zarra, T. (2012) *Odour Impact Assessment Handbook*. United States: John Wiley & Sons.
- [10] Nicell, J.A., 2009. Assessment and regulation of odour impacts. *Atmospheric Environment* 43, 196e206.
- [11] Sowka, I. (2010). Assessment of Air Quality In Terms Of Odour According to Selected European Guidelines : Grid And Plume Measurement. 36, pp.134-141.
- [12] VDI 3940, (2006). VDI 3940 Part 2. Measurement of Odor Impact by Field Inspection e Measurement of the Impact Frequency of Recognizable Odors Plume Measurement, vol. 1. VDI (Verein Deutsche Ingenieure), *Handbuch Reinhaltung der Luft*.