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Optimization of field inspection method for odour impact assessment

Zarra T., Naddeo V., Giuliani S., Belgiorno V.
Department of Civil Engineering, University of Salerno
Via Ponte don Melillo, 1, 84084 Fisciano (SA), Italy

Odour emissions are causing serious nuisance for the population, especially in the surrounding of sanitary environmental engineering plants. Extended exposure to odours generate undesirable reactions ranging from emotional stresses such as unease, discomfort, headaches, or depression to physical symptoms.
Odour assessment can be performed using two different approaches: measurement of sources emissions and/or evaluation of impact area. German Guidelines VDI3940 proposes the standardization of the field inspection method to predict the level of exposure of odours in the surrounding community. However, the main dranback of this method is high cost due to the excesive needs of assessors and long time of analysis.
This study investigates the role of the measurement elements provided with the field inspection method according to VDI3940, with a discussion of a case study, with the aim to reduce the human resources, time and costs related with the analysis. Results highlight the possibility of reducing the sampling frequency and the panel number in specific conditions.

1. Introduction

Odour effects from a variety of sources are causing a growing number of public complaints and concerns throughout the world. Odours may cause a variety of undesirable reactions in people, ranging from annoyance to documented health effects (Winneke, 1995). In communities exposed to odorous emissions, even though there may be no immediately apparent diseases or infirmities, there certainly is not an atmosphere of complete mental, social, or physical well-being (Wilson et al., 1980). Moreover, extended exposure to unpleasant odour generate undesiderable reactions ranging from emotional stresses such as unease, discomfort, headaches, or depression to physical symptoms including sensory irritations, headaches, respiratory problems, nausea, or vomiting (Stuetz et al., 2001, Zarra et al.,2008; Wilson et al., 1980, Gostelow et al., 2001). The particular and complex nature of the substances cause of the smell impact, their variability in time and related to the meteo-climatic conditions, and the subjectivity of the smell perception are the elements that delayed their regulation (Gostelow et al., 2001; Bidlingmaier, 1997).

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There are few international laws and/or define criteria of quality regarding of odours emissions from industrial sources. In particular, in Italy there are currently no regulations that deal with this problem (Frechen, 2003; Zarra et al., 2008). Odour assessment is also a critical point where the international literature have different point of view (Stuetz et al., 2001; Frechen, 2003; Zarra et al., 2008). Generally Odour assessment can be performed using two different approaches: measurement of sources emissions and/or evaluation of impact area (Zarra, 2007). Measurement of emissions can by achieved using tree different methods (analytical, sensorial and/or senso-instrumental) that have different advantages and problems (Stuetz et al., 2001; Frechen, 2003; Zarra et al., 2008). Evaluation of impact area uses generally two different methods: atmospheric dispersion modeling and/or field inspection techniques (Zarra, 2007). Atmospheric dispersion modeling predict the level of exposure of odour in the surrounding community direct from the source. This methods requires a lot of input parameter for the evaluation that don't are ever time available (identification and characterization of all odour sources from the facility in question, estimation of their odour emissions, definition of the meteorological and the terrain conditions) (Wilson et al., 1980). Field inspection techniques define the odour impact in an assessment area across an on-site analysis carried out using human panel selected in compliance of the EN13725:2003 regulation. German guideline VDI3940 defines set of instructions for standardize the field inspection method, scheduling elements (e.g. number of measurement, N; period of analysis; number and attributes of human resources) and methodology for measurement (e.g. determination of odour hours for each points, n_h; calculation of odour load for each square, OL). However, even when performed according to the VDI3940 the main dranback of this assessment method is high cost due to the excesive needs of assessors and long time of analysis (Koster, 1985).
The scope of this study was to investigate, with an discussion of a case study, the role of the measurement elements scheduled by VDI3940 for the evaluation of the odour impact in an assessment area, with the aim to optimize the method in terms of human resources, time and costs.

2. Materials and methods

2.1 Investigated area

The implementation of the field inspection method according to VDI3940 for investigate their optimization was carried out in a part of the industrial area located at the country of Salerno (SA, Italy), in the Campania Region.
The exposed study covered an area was of 1.25 Km^2. According to VDI3940, the area was divided into a grid of square. The sides of a mesh was fixed as 250 metres with the points of intersection codified with a number (n.1 – n.31) and the mesh with a letter (A – V) (Figure 1). The theoretical grid was adapted to real world area by moving the intersection points when necessary to an accessibile point of the ground.
The investigated area was originally used for only industrial activities, but over time the process of urbanization has there changed its territorial framework. The area including the wastewater treatment plant (WWTP) of Salerno, an important diagnostic center, an highway, shopping centers and residential homes.

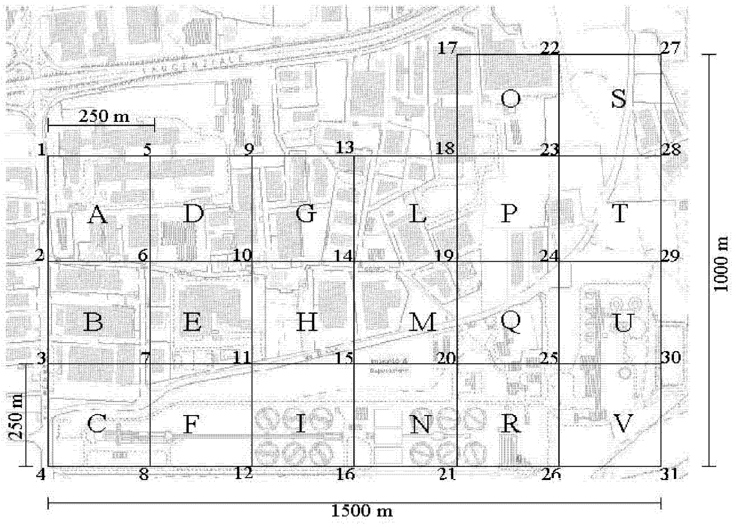

Figure 1. *Grid of square of the investigated area*

2.2 Odour monitoring

Odour monitoring was carried out according to German Guidelines VDI3940 at all corner points identified from the grid of square of the investigated area, two times a week, from April to September 2009 (critical months for odour annoyance in the investigated area).

Four odour quality category are identified in background for the assessment: sewage odour (Quality 1), waste odour (Quality 2), smog (Quality 3) and 'other odour' (Quality 4). 'Other odour' category includes a wide variety of odours including at times, pleasant ones. Five assessors, selected according to EN 13725:2003 regulation and firstly familiarised with the identified odour quality, were used.

The outings covered the period from 9 o'clock in the morning to 10 o' o clock at night. A total of 52 measurement for each corner points were carried out. For each measurement were calculated the odour hours (n_h) for each corner point and the odour load (OL) for each mesh according to VDI3940.

Weather condition (air-wind intensity and direction, temperature, humidity, pressure) were continuously detected in order to both take into consideration the effects of atmospheric dispersion of the substances emitted and perform the field inspection measurement in optimal condition (under wind, wind speed from 1 to 3 m/s, temperature under 35°C (Zarra et al., 2008).

2.3 Odour impact assessment

Odour impact was carried out according to the German guidelines GIRL (Geruchsimmission – Richtlinie) checking that the maximum frequency of odours, this being understood to mean the relative frequency of times when odours are clearly perceptible, not exceed 15% odour hours, for industrial areas.

Measurement of the meteorological parameters was carried out using a Kestrel® 4000 Pocket Wind Meter (Nielsen-Kellerman, PA, USA) anemometer and an analogical compass to define wind direction.

2.4 Optimization studies

Relatively simple statistical procedures are used to analyze the data (odour hours and odour load) collected on the investigated area.

Non-parametric tests of Mann-Kendall modified (Gilbert, 1987) are used for examine the possibility of reduction the sampling frequency analysis, through the study of the presence or absence of monotonic trends according to the procedure proposed by Belgiorno et al. (2002). In particular, the frequency analysis of the intervals of sampling ranged from two times a week to once a month for the total period of analysis (6 months) were considered. The results are compared to the results of the odour impact area obtained according to the VDI3940.

3. Results and discussion

The total odour load carried out according to VDI3940 out over all analysis period and over all assessment meshes for the investigated area amounted to 21.9% of which 16.0% was of Quality 1 (sewage odour), 3.9% for Quality 2 (waste odour), 1.1% for Quality 3 (smog) and 0.9% for Quality 4 (‘other odour’). The results shows that only the odour quality type 1 (sewage odour) exceed the limit of 15%, fixed by German guidelines to by consider significant the annoyance caused by the odours, and for this generates odour impact for the investigated area.

Table 1 shows for example the odour load calculated for the assessment of the mesh F.

Table 1. *Calculation of the odour load for assessment mesh F.*

Measurement point	**Number of measurement**	**Odour hours (n_h)**				
		Quality 1	***Quality 2***	***Quality 3***	***Quality 4***	**Total**
3	13	3	1	0	0	4
4	13	3	0	0	0	3
7	13	4	0	0	0	4
8	13	4	1	0	0	5
Total	**52** (N)	**14**	**2**	**0**	**0**	**16** ($\sum n_h$)
OL		***27%***	***4%***	***0%***	***0%***	***31%***

Figure 2 shows the odour load (OL) calculated for the investigated area for each mesh. Results shows that 12 meshes of 20 are impacted by odour of which 7 have strong odour impact.

The results of the statistical analysis of the odour hours calculated according to VDI3940, shows that it is possible to change the monitoring frequency in the mesh, from two times a month to one times a month, when his total odour hour was ≥ 1 for 3 consecutive measurements.

Table 2 shows for example the odour hours calculated for the assessment of the mesh F carried out according to the frequency proposed by VDI3940 (two times a month) and with a monthly measurement frequency.

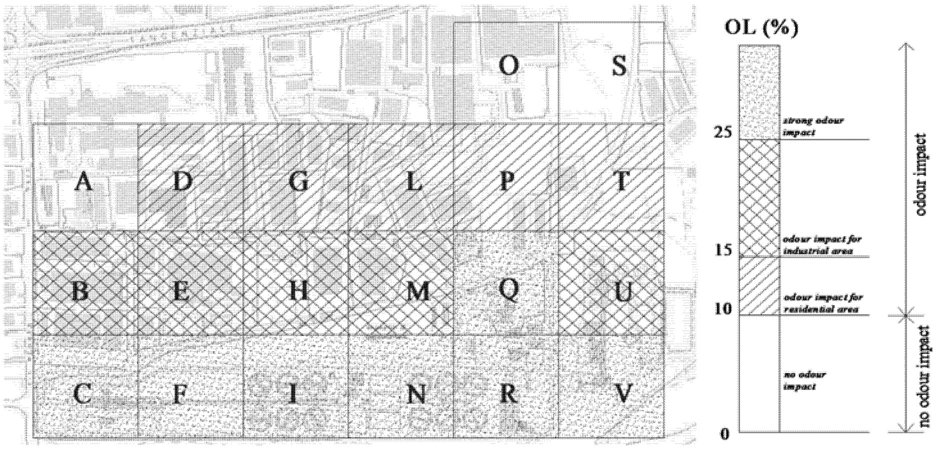

Figure 2. *Odour load for investigated area according to VDI3940.*

Table 2. *Odour hours for the point 7 of the mesh F.*

Measurement	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Odour hours (VDI 3940)	0	2	1	2	1	1	1	1	2	1	0	2	1
Odour hours (optimization)	0	2	1	2	-	1	-	1	-	1	-	2	-
		3 consecutive ≥ 1			monthly frequency								

Table 3 shows the comparison between the calculation of the odour load of the investigated area according to VDI3940 (two times a month) and the monthly measurement frequency in the mesh where his total odour hour was ≥ 1 for 3 consecutive measurements.

Table 3. *Odour load*

ID	OL (%)		ID	OL (%)	
Mesh	*VDI*	*optimization*	Mesh	*VDI*	*optimization*
A	10	10	M	25	25
B	21	21	N	38	38
C	25	28	O	8	8
D	13	13	P	13	13
E	21	22	Q	27	28
F	31	34	R	44	44
G	13	13	S	6	6
H	29	28	T	13	13
I	38	38	U	21	22
L	13	13	V	29	31

Results shows that the analysis of monitoring frequency trough monthly measurements in specific meshes does not undergo any changes in terms of odour impact area. The number of the meshes that have odour impact are the same while changing the frequency. In particular, whit optimized frequency of measurements, total odour load averaged out over all assessment squares for the investigated area amounted to 22.4% of which 16.5% was of sewage odour, 3.8% of waste odour, 1.2% of smog and 0.9% for ‘other odour’. Again, the sewage odour exceeds the limit of 15% and it’s responsible of odour impact.

4. Conclusions

Field inspection method according to VDI 3940 has been applied for the odour impact assessment in a sensitive area, for investigate the role of the measurement elements scheduled by the German guidelines, with the aim to optimize the method in terms of human resources, time and costs.

Statistical analysis of obtained results showed that it is possible to reduce, from two times a month to one times a month, the monitoring frequency in the mesh where there is a growing monotonic trend, without changing the results. In this way it is possible to optimize the number of measurements and therefore the costs and the human resources.

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