Relevance of the resident diaries method to map odour sources

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The odour annoyance in the surroundings of an industrial park in Belgium was evaluated through diaries completed by 42 residents during about two years. The studied area includes 13 potential odour emitting facilities. The questionnaire aimed at providing twice-daily an odour annoyance rating on a 5-level scale together with an odour type.
Data processing and interpretation stressed more particularly on the two types of result that can be extracted from resident diaries, i.e. annoyance percentage and annoyance level. The plausibility of the responses is examined as well. Mapping odour sources in this particular case of multi-source facility is made possible through the use of odour roses. With respect to first results obtained for year 2008, more recent data provide more detailed information concerning the role of each facility to explain the whole odour annoyance. The resident diary method proves to be relevant, especially in the case of an industrial area, provided that validation checks are performed to insure the data reliability.

1. Introduction

Global odour annoyance generated by multi-source facilities, like industrial complexes, cannot be assessed by usual sensory or analytical methods. Socio-economical factors, like the relations between the resident and the different companies, the gender or time spent at the current address, the absence or the presence of background odours influence the odour acceptability (Steinheider and Winneke, 1993). Additionally, in the case of multi-source industrial plants, both the background itself and the emerging odours are complex mixtures of different odour types, which fluctuate with time. Hence, it is essential to make a global assessment of the odour annoyance, using the residents themselves as measuring tools. Such a monitoring technique is presented in this paper, applied to a multi-source industrial area and with the aim of demonstrating the concept,

particularly appropriate for environmental management. The relevance and the reliability of the resident diary method are particularly discussed.

2. Material and method

The case study concerns an industrial park in Belgium in an urban area. Prevailing wind directions are from North-East and chiefly South-West. Fig. 1 shows the studied industrial area with main roads and the 13 companies involved in the global odour annoyance.

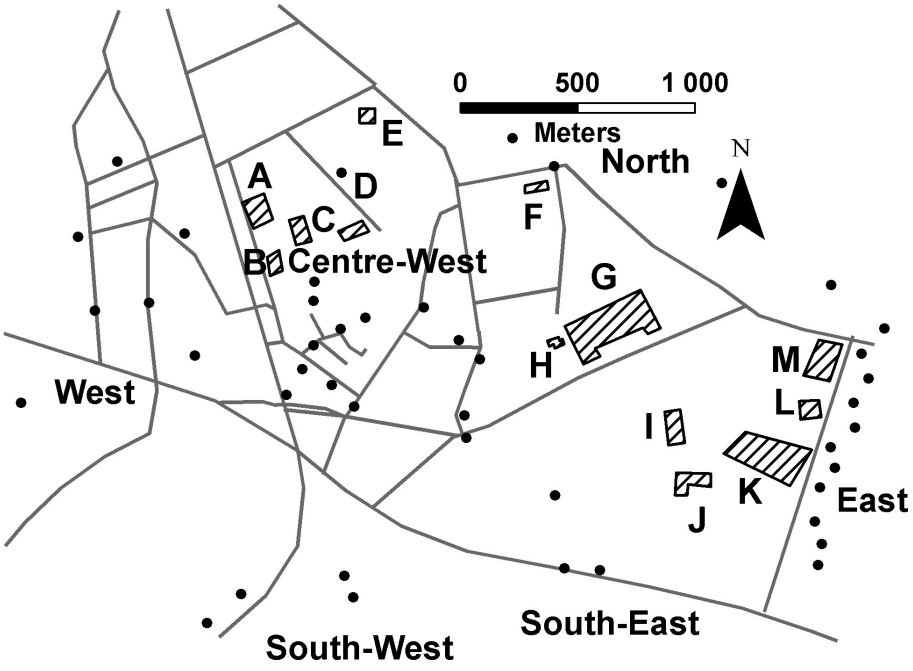

Fig. 1. Location of observers (black dots) and companies (cross-hatched polygons).

All 13 companies are potentially odour emitters. Table 1 indicates their activity.
The network of volunteer residents was created in September 2007 on initiative of Ecovie, a local environment association. The university research group and Odometric were involved as partners in the study in March 2008.
Only two persons were particularly trained to test their nose, but two meetings were planned with the panel members in order to present the first results and to redefine the frame and the instructions of the procedure. Additionally, a preliminary survey was conducted through the panel members to better describe their general profile. For this, the proposed series of questions was adapted from VDI 3883 Part 1 guideline (VDI, 1997).

Table 1 : List of the 13 companies located in the industrial park

Label	Activity	Label	Activity
A	Slaughterhouse	H	Glue and latex-based products
B	Sausage manufacture	I	Potato crisps
C	Animal by-products rendering	J	Poultry slaughterhouse and frozen products
D	Cosmetics and pharmaceutical products	K	Urban waste water treatment plant
E	Construction waste recycling	L	Frozen vegetables
F	Potato-based products	M	Linseed oil-based products
G	Chemical products		

The requirements for answering the questionnaire are: if possible, daily observations, two times a day; two imposed periods (7-9 am and 6-8 pm), but any particular observation outside those ranges can be mentioned; sniffing near their home, but outside; estimation of the odour annoyance rating on a 5-level scale (with 0=no annoyance to 4=unbearable), selection of an unique odour type among a list of 14 terms,

A first investigation concerns the first half of year 2008, with 42 involved residents and a second analysis is made especially for the period September 2008-September 2009, with 30 residents. As seen on figure 1, enrolled residents (black dots on the figure) cover all the zones surrounding the industrial activities and can be distributed into 6 spatial clusters (West, Centre-West, South-West, North, South-East, East). For odour type and odour rose analyses, all residents are considered, but for cross analysis between residents, only those who responded with more than 33% frequency (more than 33% of all possible twice-daily period entries) are kept (i.e. 19 for the first period and 21 for 2008/2009 period).

3. Results and discussion

A first essential result deduced from the odour ratings data file is that about 80% of the observations correspond to “no-annoyance” (0 on the odour rating scale). This means that, overall, a majority of time periods are odour-free (or at least annoyance-free) in the neighbourhood. Such finding leads us to consider two types of results. The first one is related to the odour annoyance duration and is defined as the percentage of odour annoyance rating above zero over total responses. The second one is the annoyance rating itself, for responses above 0.

Concerning firstly annoyance percentage, a clear distinction can be observed between zones. Large annoyance percentages are observed for residents living at the centre of the industrial park and for those living at the North-East of the park, i.e. in the direction of prevailing winds. The average annoyance-percentage is 17% but is not constant over the

year, with two "peak periods" in April-May and in September. That can be due to the time evolution of industrial activities, but also to weather conditions for those periods.
On the contrary, the annoyance rating is nearly constant over the whole year (with an average value in the middle of the scale). That means that, when an odour is perceived, the degree of annoyance is about always the same.
On shorter time scales, intra-week variations show logically less annoyance during week-ends while daily variations show more annoyance during working periods.

Such findings are logical and do not provide any original information with respect to common sense. More interesting results are obtained when breaking down the global odour annoyance index into the contributions of various odour types and of various spatial zones.
Figure 2 shows the usage rate of two odour types, “potato, fried food” and “animal carcasses” distributed among the different days of the week (Fig. 2a) and among different resident zones (Fig. 2b). The first type should concern essentially companies F and I, located in the East part of the park, and the second one should be typical of companies A and C, in the West part. Logically, the “animal carcasses” odour is most smelled in the Centre-West zone and the “potato” odour is most often detected in the East zone, but is also present in the Centre-West and in the North zones, which are not so far from company F. Regarding time evolution during the week, the “potato” odour is highly reduced during the week-end, corresponding to the reduced activity of the companies, while the odour of “animal carcasses” is more constant. Those trends confirm intuition, as the storage of animal carcasses during the week-end continues to be an odour source, even if activity is reduced (Nicolas et al, 2010).

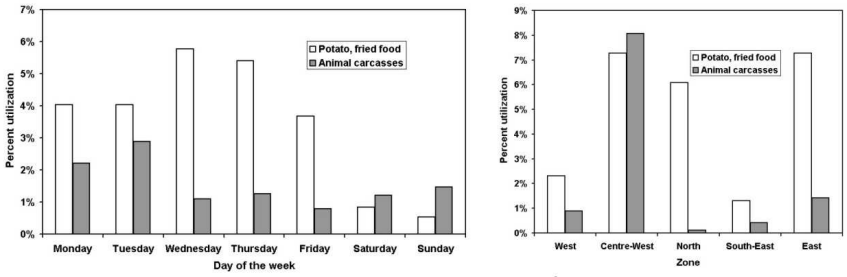

Fig. 2. Distribution of the utilization rate of two odour types among the days of the week (a) and among the observation zones (b).

For this kind of approach, involving social participation, the subjectivity of residents takes part of the odour annoyance notion, and does not be discarded for data interpretation. However, one has to avoid partiality in responses, when people try to accuse a given company. So, one has to cross the annoyance index supplied by residents with a more objective variable, such as the measured wind direction. That is the aim of odour roses, which is constructed like the usual wind rose, but by plotting the odour annoyance rating in place of wind velocity occurrences on the radii of the circular diagram for each wind sector. It consists of selective average of annoyance rating for all sectors of the wind rose. As wind direction is recorded in terms of its origin, the rose

should normally point at the odour emission. Fig. 3 shows 5 odour roses calculated for the average annoyance rating for 5 defined zones. This diagram is reassuring: each of the 5 odour roses points towards the main odour emission sources of the industrial area and does not reveal any new unexpected source. The absence of illogical odour roses should confirm the reliability of the resident observations.

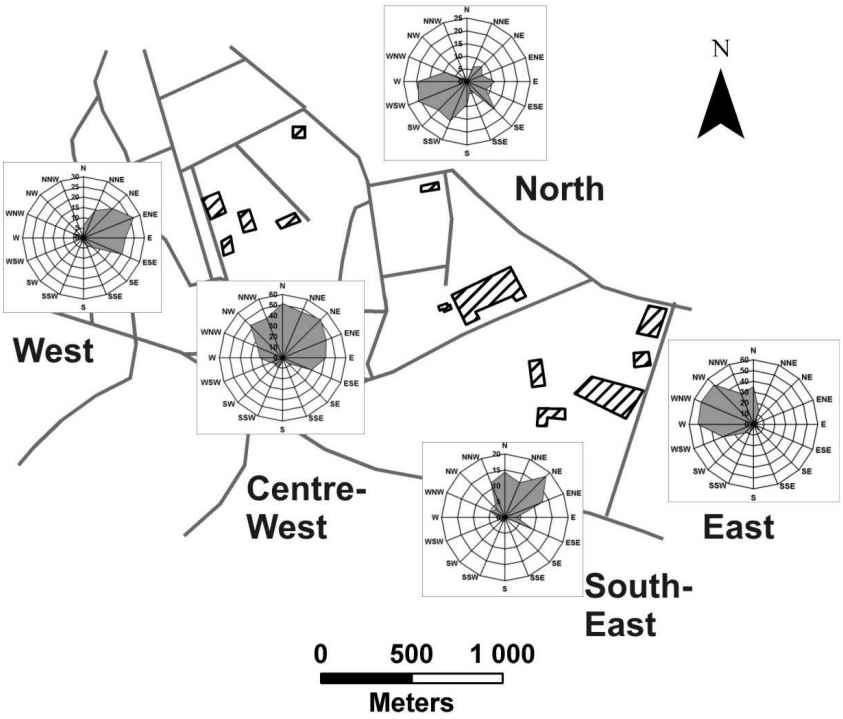

Fig. 3. Odour roses for the residents of 5 zones around the industrial park

Less obvious findings can be obtained by breaking down odour roses into the contributions of various odour types. Fig. 4 shows two odour roses corresponding to zones Centre-West and North for odour type “potato, fried food”, which could be used to identify the most annoying source of potato and fried food odour.

Two companies, F and I, are actually potential emitters of those odour types. Figure 4 suggests that residents are more annoyed by company F than by company I.

That specific result is now giving rise to a positive feed-back, as company F has decided to improve its odour abatement system. For that matter, since the beginning of 2009, the resident diary follow up has changed its objectives: the aim is now to evaluate the evolution of odour annoyance resulting from improvements in odour management. Besides the simple monitoring of odour events, the resident diary methods proves thus to be a good way to progress towards better communication between companies and residents, leading also to public and authorities awareness for odour problems.

More generally, since the first report concerning mostly year 2008 (Nicolas et al., 2010), the analysis of data for the period September 2008-September 2009 brought more precise information concerning the role of each company in the global odour

annoyance in the region. Moreover the average trend seems going to a decrease of the odour annoyance (to be confirmed).

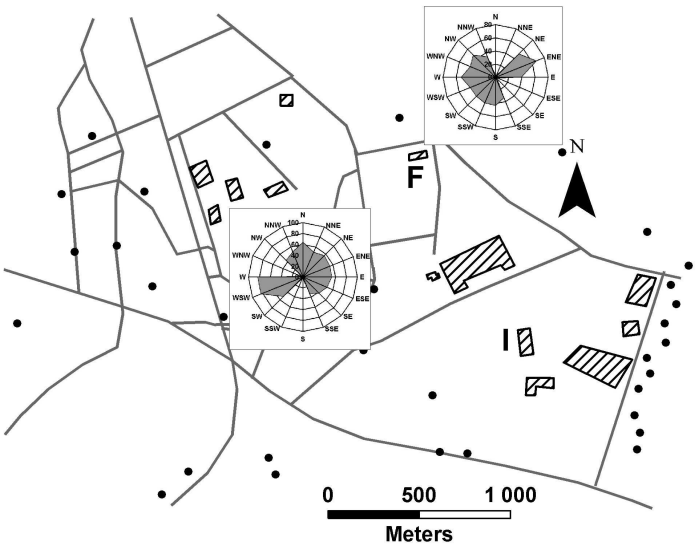

Fig. 4. Odour roses corresponding to two zones for the odour type "potato, fried food".

4. Conclusions

Using resident panelists to assess odour annoyance proves to be a relevant method, because residents stay in the designated area and are exposed to the odour frequently. Odour diaries statistics allows to focus on the most worrying sources, to highlight unpredicted ones and to improve the communication between companies and public.
Major drawbacks of the method is the lack of motivation for people living outside the exposed area, which generally results in giving up the results corresponding a potential reference control zone, together with a possible bias due to people partiality.

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