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Field Inspections According to prEN 16841-1:2015 in a Naturally Evolved Neighborhood of Industry and Living Areas. State-of-the-art-technology of a Comprehensive Data Collection, Interaction of Different Sources and Effects on the Perceiving Citizens

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An increasing complaint situation on odour nuisance in the cities Mainz and Wiesbaden in the Rhine corridor brought the ministries of the two German counties Hesse and Rhineland-Palatinate to the decision that comprehensive field measurements are necessary to determine the real impact situation. The Olfasense GmbH (formerly Odournet GmbH) conducted this huge field inspection on behalf of the ministries. The measurement area of around 7.500.000 m² was covered with a grid of 157 measurement points and 100 grid cells. Over half a year a panel of 21 assessors conducted field measurements and assigned the occurring odours to 15 defined odour characters.
The article will describe the advantages of the used web technology in comparison to the former proceeding with paper registration of odours especially due to the quick access to the results during the whole investigation period. This has several benefits for the local authorities and plant operators. It will present the results of the measurements according to prEN16841-1 and the Guideline on Odour in Ambient Air (GIRL) as well for the complete odour situation as for single odour characters. In parts the results showed a clear exceedance of the German limit values (allowed frequency of odour perception) for living areas. We will provide a discussion on the influence of odours of different sources and different characters occurring in the same period of time (odour hour) and the attempt to relate this to the effects on the citizens.

1. Introduction

In the area of the cities Wiesbaden and Mainz located at two sides of the border between the counties Hesse and Rhineland-Palatinate several commercial and industrial areas are located in close neighborhood to living areas.
In figure 1 as well as in table 1 those companies are listed which can be a source of odour according to their raw materials or processes. Some have been in the focus of the citizens and cause for odour complaints delivered to the authorities.
To quantify the odour impact in this area and to determine the potential sources, a cooperative working group of representatives of the involved authorities and ministries was formed. In a first step this working group calculated the odour impact on basis of available emission data. Soon it came clear that this attempt could not give a comprehensive view on the situation as the emission data was available only for some of the potential sources. Hence the working group decided to detect the odour impact situation by an odour measurement program. The measurement was then conducted by the accredited measurement laboratory of Olfasense GmbH (at that time Odournet GmbH) as a grid measurement over half a year.

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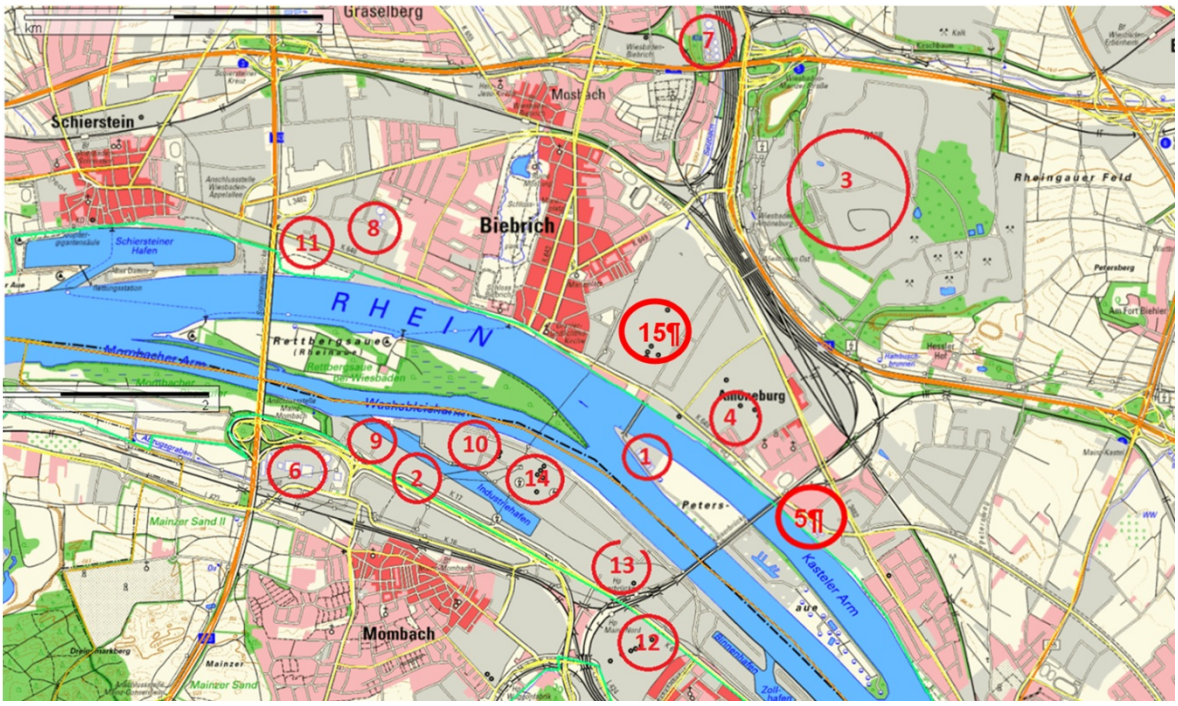

Figure 1: Map of Wiesbaden (north of the Rhine) and Mainz (south of the Rhine) with the emitting companies

Table 1: Odour emitting companies

Position	Operator	Kind of Plant
1	InfraServ GmbH & Co. Wiesbaden KG	Biological Wastewater Treatment Plant
2	Cargill Deutschland GmbH	Oil Mill
3	Disposal services of Wiesbaden	Landfill Wiesbaden
4	Dyckerhoff AG	Cement Production
5	Disposal services of Wiesbaden	Pumping Station
6	Municipal entity Mainz	Central Sewage Plant Mainz
7	Disposal services of Wiesbaden	Main Sewage Plant Wiesbaden
8	Disposal services of Wiesbaden	Sewage Plant Biebrich
9	Nestlé Deutschland AG	Coffee and Cocoa Production
10	Wepa Hygieneprodukte GmbH	Paper Production
11	Schwenk Dämmstofftechnik GmbH	Production of Glass Wool
12	Römheld & Moelle Maschinen- und Apparatebau GmbH	Iron Foundry
13	Mogat-Werke Adolf Böving GmbH	Roofing Membrane Manufacturer
14	Quinn Plastics GmbH	Chemical Industry
15	Miscellaneous companies, e.g. Industriepark Kalle-Albert	Several Plants of Chemical Industry

1.1 Regulations

In Germany odour nuisance is regulated according to the Federal Pollution Control Act. § 3 of the Federal Pollution Control Act defines odour emissions as a harmful effect on the environment when they lead to significant nuisances to the general or the neighborhood. The assessment if significant odour nuisance appeared and thus caused serious environmental damage is done by comparing the determined impact value with the exposure values of the German Guideline on Odour in Ambient Air (GIRL). A substantial odor nuisance is present when the total burden of the pollution exceeds the limit values in Table 2. The exposure values according to GIRL are odour hours expressed as relative odour hour frequency. Thus the exposure value of 0.10 is complied with, as long as not more than 876 odour hours are perceived per year (8760 hours per year times 0.10).

Table 2: Exposure values according to GIRL for different areas of use

Residential / Mixed Area	Industrial Area	Rural Area
0.10	0.15	0.15[1]

[1]The exposure value for rural areas is valid only for odours from agricultural origin.

For the determination of odour impact in ambient air field inspections are used. These are conducted as grid measurement according to the German VDI guideline 3940 sheet 1 as well as according to the new draft of the European Standard prEN16841-1.

1.2 Principle of measurement

The grid method is a statistical survey method which is applied over a sufficiently long period of time. The result will be a representative map of the exposure to recognizable odour, spatially distributed over the assessment area and determined under meteorological conditions that are assumed to be representative for the local meteorology (e.g. the last ten years).

The odour hour frequency is an odour exposure indicator and can be used to assess the exposure to recognizable odour originating from one or many specific odour sources in a particular area of study. It is determined for one or more assessment squares configured as a grid of measurement points.

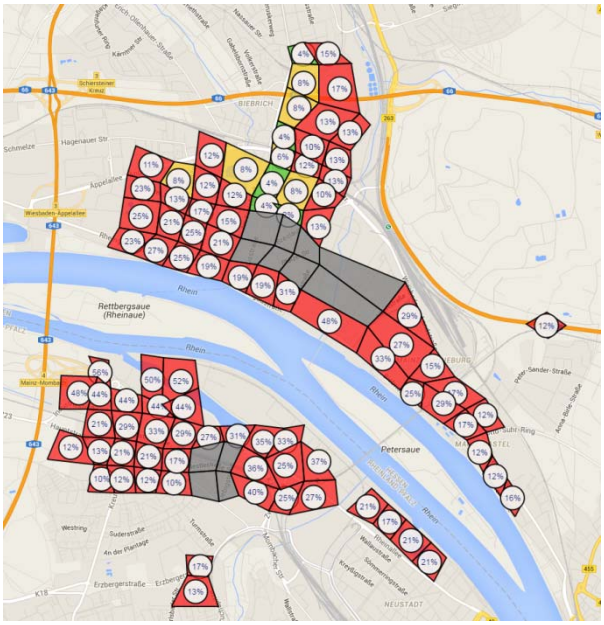

Figure 2: Map with the grid of measurement points and the corresponding assessment areas

The assessment area has a size of at least 600 m from the edge of the installation site to the outer border of the assessment area or a size of a radius of 30 times the highest stack height from the emission focus. The squares have a size of 250 m x 250 m or – depending on the measurement task – smaller, e.g. 125 m, 100 m or 50 m side length. The grid will be fixed on the map first but the final definition of the measurement points will be done according to the real locations with respecting the use of the location and its surroundings, the distance to the next buildings and potential additional odour sources.

The recommended survey duration differs between the prEN 16841-1 and the VDI3940-1. According to the prEN 16841-1 it is the period of 12 month with the allowance to shorten the duration to six month. It has to be ensured that for a survey duration of half a year each assessment square is measured with at least 52 single measurements (13 measurements for each measurement point). The VDI guideline recommends a survey duration of half a year with the possibility to extend the duration to one year.

During the measurement period each measurement point is measured repeatedly at a predefined survey schedule. As the measurements have to be evenly distributed over the season, the time of the week and the time of the day as well as the single measurement points of an assessment square have to be measured independently of each other (not on the same day and no adjacent measurement points of a single assessment square in one round) the planning of the schedule (date and time) is necessarily carried out before the start of the measurement.

Further factors have to be respected: Measurements should not be carried out on consecutive days (this is only allowed for rescheduled dates), panel members shall not assess more than 12 points during one measurement round, after four single measurements all times of the day (morning, noon/afternoon, evening, night) should be covered, the panel members should be employed with roughly similar frequencies, the staff managing the odour sources should not be informed on the schedule and the odour-relevant discontinuous processes shall be documented during the survey.
Finally the panel for the measurements needs to be recruited and selected. A panel needs to consist of at least 8 panel members according to prEN 16841-1 (and of at least 10 panel members according to VDI 3940, sheet 1). To check the suitability of the panel members several factors have to be taken into account. The panel members shall meet a clear code of behaviour as defined in prEN16841-1 and VDI3940, sheet 1 and they need to fulfil the requirement of the EN13725:2003 concerning individual variability and sensitivity.
Each single measurement is conducted to determine whether the test result is an odour hour or not. Therefore a panel member conducts the single measurement at a measuring point for 10 minutes. He inhales ambient air every 10 seconds and evaluates the presence or absence of odour and the corresponding odour type. After the total measurement duration 60 individual observations at the measurement point are obtained. When a particular odour reaches or exceeds a percentage of time of 10 % (presence of odour is detected at six or more observations) the result is classified as odour hour. To calculate the result of odour hours for one assessment square the odour hours of the four measurement points are summed up and the result is then divided by the amount of total measurements at this assessment square.

1.3 Measurement Details for the described Grid Measurement

The measurement details for this huge field inspection in the Rhine corridor were defined together with the authorities and ministries. The assessment area of around 7.500.000 m² was covered with a grid of 157 measurement points and 100 assessment squares as shown in figure 2. Over half a year from 13/07/2011 to 27/01/2012 a panel of 21 assessors conducted field measurements and assigned the occurring odours to the following odour types.

Table 3: Odour types

Identification	No. of Odour Type	Description	German Description
Ass	1	Waste water, sweet, sulphurous	Abwasser, süßlich, schweflig
Afp	2	Waste water. Faecal, pungent	Abwasser fäkal, penetrant
D	3	Landfill, waste, pungent	Deponie, Müll, stechend
Mü	4	Waste, dull	Müll, dumpf
HA	5	Resinous, burnt brake pads	Harzig, verbrannte Bremsbelege
Gu	6	Burnt rubbery smell	Gummiartiger Brandgeruch
Gi	7	Foundry, metallic, coal	Gießerei, metallisch, Kohle
CL	8	Chemically, solvent	Chemisch, Lösemittel
CF	9	Chemically, fishy	Chemisch, fischig
DP	10	Roofing paper, bitumen	Dachpappe, Bitumen
KA	11	Coffee	Kaffee
KK	12	Cocoa	Kakao
RA	13	Rape, Pea soup, sulphurous	Raps, Erbsensuppe, schweflig
HB	14	Domestic heating	Hausbrand
Sonstiges	15	Others (e.g. traffic, waste bin)	z.B. Verkehr, Mülltonne, Küchenabluft,…

The measurement points were divided into 16 rounds, each of 8 to 12 measurement points, due to the high number of total points. This resulted in four panelists doing the measurement at the same time in different areas of the cities Mainz and Wiesbaden.
During preparation of the grid measurement the training of the panelists was of special interest as the number of different odour types was high. Thus the panelists were trained on the one hand with Sniffing sticks as well as with real samples. They had to assign the samples to a defined odour description. To ensure that the perception in the field was consistent for all panelists a trained staff member of Olfasense GmbH accompanied the first measurement of each panelist. To ensure that the panelists apply the method and the evaluation correctly spot checks were carried out. Additionally positioning and timing were checked and documented by the OFIM app (Online Field Inspection Manager) which was used for the measurement.

2. Used technology

The used technology OFIM (Online Field Inspection Manager) consists of a central online platform, in interaction with a mobile application for smart phones (Mannebeck). With the system a large number of processes can be automated and optimized.
During the planning phase, site plans and map materials are used to define the inspection points and the grid areas for the evaluation area. The potential odour characters are determined with the help of an emissions register. Additionally, the time and organisational planning is set up, so that a balanced allocation of the inspection dates regarding scheduled time, weekdays and odour inspectors is ensured. Already during planning the advantages of this system came clear: it was much faster and also more flexible than the old-fashioned way to use pen and paper.
When the data collected during an inspection has been sent by an inspector and is available to the staff member responsible for the project, he/she performs a plausibility check, so that the validated data can then be incorporated in the evaluation. This allows a fast overview over the measured results for the laboratory as well as for the client who can autonomously and promptly follow the results.
The central online platform further allows a fast result display for the overall odour or for single odour types. As also the count value for the odour hours (positive single measurements) can be changed the uncertainty of the odour hour frequency can easily be calculated and shown. Usually the uncertainty is given for those observations with more than 2 and those with more than 8 positive observations. The results define the upper and lower limit of the uncertainty interval.

3. Results

The results of the inspections are shown in figure 3 for all industrial odours. The colour definition can be chosen in our webtool Ortelium according to the calculated odour frequency. In this case it is set to green <5%; yellow between 5% and 10%; red >10%).This refers to the fact that the impact in residential areas shall be evaluated. For residential areas an exposure value of 0.10 (10%) is maximum. According to the German GIRL the following odour types are not included in the calculation of the odour frequency as they originate from household sources. Only sources from plants are to be included in the calculation of the results.

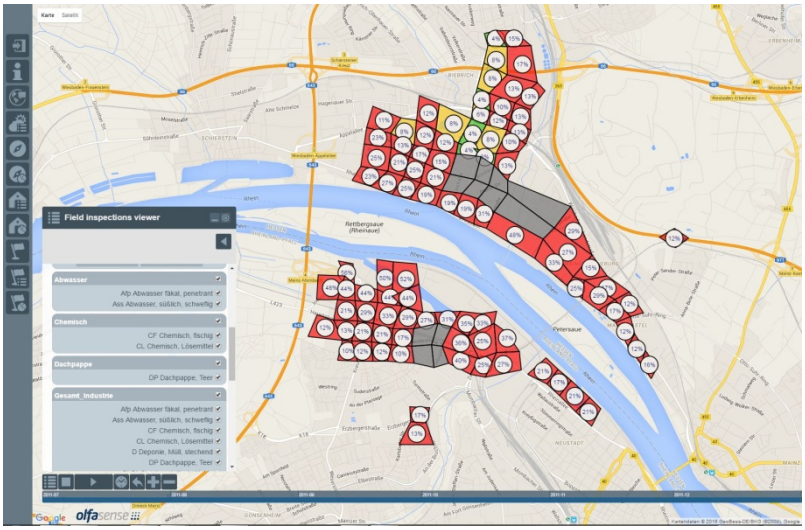

Figure 3: Map with the calculated odour hour frequency in percent for all industrial sources

3.1 General Odour Impact Situation

The perceived odours show the complete range of industrial odours during the measurement. Figure 3 shows that the odour hour frequency exceeds the limit of 10% for the majority of the grid areas. Near to the industrial areas the determined values even exceed 40%. This significant exceedance of the limit values is not consistent with the nuisance situation. Concerning the measured odour hour frequency the nuisance situation and thus the number of complaints could be expected to be much higher. This evidence suggests that the same odour hour frequency for only one odour type provokes a stronger nuisance than an odour hour frequency from different odour types. At the moment, there is neither a research background nor the legislative background to include this experience in the evaluation of results.

3.2 Single Odour Characters

As far as possible, single odour types were assigned to specific industries. A clear allocation of odour types to specific plants or companies was only possible for Nestle (coffee, cocoa) and for the company Cargill (rape, pea soup, sulphurous). The odour types allocated to the mentioned plants were perceived more often and more dominant than other odour types. Additionally, also odours related to waste water or chemical odour were perceived often and dominant but due to different emitting plants the odours could not be clearly allocated to a specific plant or company.

Table 3: Maximum odour hour frequencies for single odour types

Odour type/s (No. of Odour Types)	Maximum odour hour frequency
Waste water (1, 2)	29%
Chemical Odour (8, 9)	21%
Roofing paper, bitumen (10)	6%
Foundry (7)	8%
Landfill, waste, pungent (3)	4%
Burnt rubbery smell (6)	8%
Resinous, burnt brake pads (5)	6%
Waste, dull (4)	4%
Coffee, cocoa (11, 12)	21%
Rape, pea soup, sulphurous (13)	21%

4. Conclusions

For a grid measurement of a size as here described it is very helpful to use a webtool concerning the processing of data in preparation, proceeding and evaluation. The main advantages are to find in relation to quality and velocity from collection to presentation of data. Concerning the impact situation the ambition of both surveillance authorities is to take measures to reduce the odour hour frequencies in the impacted areas. Therefore plant-related measures have to be taken and the effect needs to be monitored. As the current impact is very high and the number of issuers is quite large the reduction of the odour hour frequency is a major challenge for the future.

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