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APPROACHES FOR HOLISTIC ODOUR IMPACT MANAGEMENT

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Abstract

Environmental odour management today offers a variety of building blocks, ranging from the use of state-of-the-art technology to the implementation of various methods, which are based on national and international guidelines and standards. These range from odour monitoring approaches using trained human sensory panels and citizen science, real-time and forecasted dynamic dispersion modelling, trajectory and back-tracking calculations, but also sensor systems which are making use of gas sensors to detect and quantify key odorants of odour sources. Although all of these technologies and methods can help to increase the understanding of potential origins of odour related problems, most solutions available in the market only allow an isolated consideration of the acquired data. Depending on the specific scenario and related questions, however, the right combination of these building blocks is often key to get full clarity on the odour emission and / or impact situation. A flexible platform like Ortelium allows to combine data channels, so that a more meaningful picture of the odour situation can be established. To facilitate and efficiently manage the process of finding appropriate measures to resolve odour related problems in due time, such a holistic solution digitally streamlines data acquired from the chosen technologies and implemented methods and puts it into relation. An overview of existing technologies and methods will be provided as a basis for practical examples of possible combinations in existing use case scenarios in the wastewater and (petro)chemical industries.

1. Introduction

Odour management today has a broad spectrum of tasks and responsibilities which can be supported by a variety of existing methods and technologies that have become best practice across the world. As odour management goals are highly individual it becomes important to understand which of the methods and technologies available can contribute relevant information to meet these goals. The right selection and combination are therefore the basis for any odour management solution. A summary of common odour management scenarios will be provided in the following chapter.

2. Common odour management scenarios

2.1 Industries

- need to prove that they comply with national regulations on odours (usually this needs to be tested and proven through a third party)
- want to measure and test the performance of odour abatement and mitigation technologies to find out if the systems work as intended and achieve the performance levels that the manufacturer advertises
- want to continuously monitor operating processes for odorous emissions to understand better when they are potentially causing an odour impact
- want to investigate if incoming complaints are valid and odours perceived by the community are originating from their odour sources
- need to be able to provide strong evidence that their company is not responsible for odour complaints which have been filed against them
- want to improve understanding of the odour impact of their site and which sources and processes are the most relevant ones, giving them the opportunity to optimise processes towards a minimal odour impact
- want to pro-actively avoid complaints if possible, by forecasting potential impacts before they occur

2.2 Authorities / Municipalities

- need to actively manage and mediate in complaint situations between communities and industries
- need to understand which industrial sites in industrial cluster areas are contributing how much to the total odour impact and nuisance level in order to impose restrictions on the perpetrators and to resolve problems related to odour nuisance
- need to ensure that all companies emitting odours are complying with national regulations related to odour management
- want to keep relevant stakeholders informed about the odour impact and actions taken to resolve existing problems

3. Overview of methods and technologies applied in odour management processes

The following table gives an overview of methods and technologies used in odour management processes, describes applications and provides information on Pros and Cons.

Table 1: Overview of methods and technologies applied in odour management processes

Method / Technology	Purpose / Used for	Pro	Con
Olfactometry a) Dynamic Olfactometry (EN13725)	- Determination of odour concentration from samples taken at odour sources - Results provide input parameters for dispersion modelling	- Standardised - Human sensory analysis ensures the human perception of the odour sample is represented	- Discontinuous method - May not cover variations of the odour concentrations at different days or across different seasons - Can only be provided by odour laboratories

b) Field Olfactometry (Not standardised)	- Self-monitor in-field odour impact - Validate dispersion modelling results - Fenceline measurements	- Relatively cheap - No in-depth odour expertise needed	- Not standardised - Operator bias - Not EN13725 compliant - Results are not legally binding in most countries
Field Inspection a) Grid method (EN16841-1)	- Impact assessment in complex industrial cluster areas with many different odour sources - Understanding the individual contribution of each industrial site odour source	- Can be done at the potential impact location - Measures the impact as it is actually perceived by a human sensory panel - Statistical method, covering all times of the day and year (provides representative results for a full year) - Uses independent objective panellists for the measurement	- Requires a significant amount of planning and preparation - Time- and labour-intensive method - Scheduled inspection plan does not allow to do spontaneous inspections as a cross-check for incoming complaints - Requires qualified odour lab and panellists to plan and carry out the inspections - An unrepresentative meteorological situation may lead to unrepresentative results
b) Plume method (EN16841-2)	- Estimation of the total emission rate of a source based on the plume extent, using reverse dispersion modelling - Determination of the plausible extent of potential exposure to recognisable odours - Measurement of the extent of the recognisable odour plume downwind from a source	- Measures the impact as it is actually perceived by a human sensory panel - Measurement of the actual odour impact during odour intensive processes is possible - Uses independent objective panellists for the measurement	- Measurement is dependent on the weather conditions at the specific day of measurement - Only evaluates the odour impact situation at a certain day (spot check)
Sensor monitoring – general (Not standardised)	- Continuous sensor monitoring of key odorants (usually via	- Can operate 24/7 - Can provide information about potential	- Does not measure 'odours', but rather certain odorants in

	MOS, EC, PID) Depending on the scope of monitoring the goal is to achieve the following: a) Absence / presence of 'odours' b) Classification of 'odours' c) 'Odour' intensity / quantity Depending on the scope of measurement the location of sensor systems can be: 1. Source (stack) 2. Fenceline 3. Receptor point	variations in odour intensive processes - May allow to indicate increases from a standard baseline value in a given time period in order to provide evidence for times of higher odour emissions or impact at the sensor location	more complex gas matrices - Gas sensors work fundamentally different compared to the human perception of odours as Böker (2014) describes - Sensors may be 'blind' towards some odorants -Sensor cross-sensitivity with other gases - Gas-unspecific sensors will also respond to odorless gases - Influence of humidity - Sensor drift - Individual ambient air background needs to be factored in - Gas concentrations of key odorants can be below the sensor detection limit
Dispersion Modelling (general)	- Modelling of potential impacts of odorous activities, either in combination with estimated emission data or with measured emission data	- Easy and often cost-effective alternative to impact measurements - Can provide valuable insights about the potential odour impact and the influences of different meteorological conditions, independent from variations on the emission side -Acknowledged method for the determination of odour impact in planning and approval procedures	- Is only a computer simulation and thus a model of reality, not an actual, measured impact - Accuracy / reliability of the results depend on the quality of the input data and model - Overlapping of different odours cannot be calculated (overestimation)
a) Defined time period (1	- Meet defined re-	- Can provide an esti-	- Does not provide

year)	quirements and prove compliance for receiving or maintaining operating permissions	ated annual 'footprint' of the odour impact based on representative annual weather data for a specific location - Effects of different measures to reduce odour (e.g. change of source location, abatement technology) can be simulated	information how the odour impact was at a certain moment in time / at a certain event
b) Historical	- Review and investigate a past situation	- Cross-check and validate past complaint situations - Can make use of measured weather data from local stations	- Does only allow to take a look into the past. - Cannot help to avoid future impacts, unless the reason for the impact was identified in the investigation process
c) Real-time	- Understand the current odour dispersion situation better and take corrective action if needed (and possible)	- Provides an understanding of the current odour impact situation and enables companies to initiate corrective actions if possible	- Only allows to react on an impact situation when it already occurred - Does not help to proactively take corrective actions
d) Forecasting	- Predict and / or prevent odour impacts pro-actively	- Allows for pro-active action to avoid potential impacts or to at least inform about potential odour nuisance	- Forecasted weather data does not necessarily reflect the actual weather situation that is later observed in reality
Community Engagement / Crowdsourcing (Citizen Science) / Complaint Management	- Resolve and diffuse conflicts with communities due to odour impacts of odorous operations - Participation of communities in the process instead of fighting against the industry	- Provides the opportunity to interact directly with the people affected by the odour impacts - Can help to diffuse conflicts by the means of active engagement (participation of the community) and open communication between the stakeholders	- Requires validation of complaints on the basis of objective data / information to avoid abuse of complaints as political tool - Requires dedicated human resources to investigate complaints and to follow-up the communication process

4. Possible combinations of methods and technologies in different odour management scenarios

All technologies and methods shown in Table 1 have unique pros and cons and, therefore, can help to address and resolve very specific problems. In countries in which odour legislation exists, the use of specific methods may be mandatory in certain scenarios. For all odour management tasks which are not mandatory according to national legislation it is very important to understand which specific problems the odour management process is supposed to address and to ensure that the methods and technologies used are carefully selected to meet the associated goals. The following examples outline how a combination of different methods and technologies may be used to support certain odour management tasks. The Ortelium Web Platform was used to streamline the data in a centralised application to allow for a holistic analysis and visualisation of results from different data sources.

4.1 Analysis and validation of an existing complaint situation

In many countries there is no standardisation on how to deal with odour complaints. It is important to understand that good communication is a key factor to diffuse these scenarios and that any kind of data used to validate a complaint needs to be accompanied by a communication process. A structured complaint validation process which is accompanied by an open communication process achieves two important goals. On an objective level it provides clarity on how to receive complaints and ensures that the information collected can be centrally managed, analysed and followed-up. On a relationship level, it facilitates interaction with the affected communities by signalling responsibility and willingness to cooperate. It further shows respect for the situation of the people affected by odour nuisance. In order to provide a solid foundation for a validation and communication process, it is recommended to provide a standardised form for submitting complaints online. This helps to have a consistent data set which also allows for comparability and statistical analysis. For each complaint a description of the odour character, the exact time of observation and the location should be the minimum data recorded. Additional information such as the perceived intensity or detailed descriptions can provide useful extra information. Access to local weather data is required to compare time and location of an odour observation with the location of odour sources and wind direction. In order to allow for an even more accurate validation, sophisticated reverse trajectory analysis may be used to backtrack the pathway of an odour observation to the potential odour source. This way it can be easily checked at first sight if the odour observation could be originating from a potential odour source. Lastly, the results of a validation process should be communicated back to the complainant in order to provide feedback on their observation which is intrinsically linked to an expected feedback and or action to be taken. Combining these elements in one system not only increases efficiency of the processes it also provided a basis for internal or external reporting.

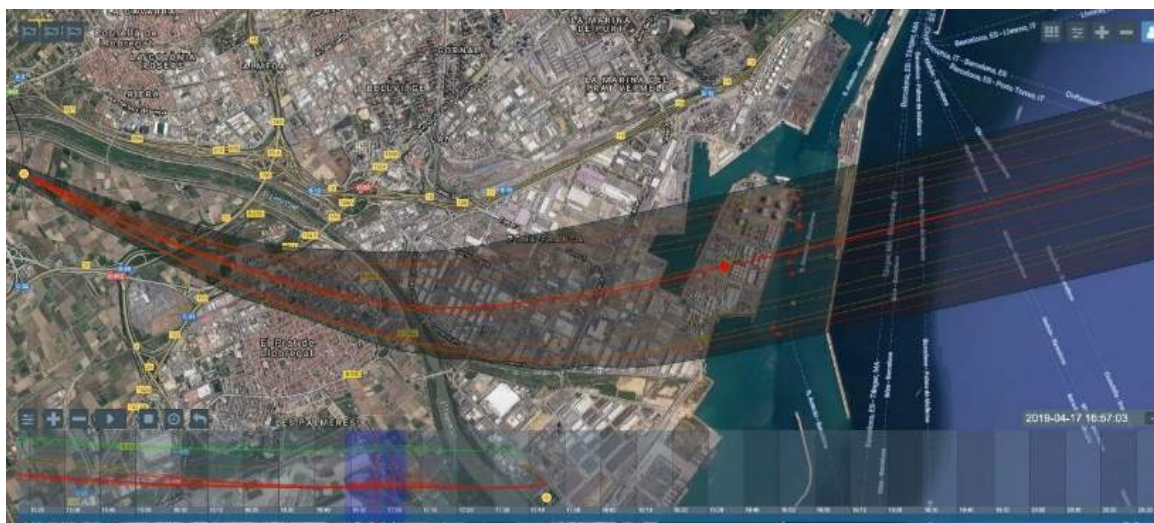


Figure 1: Example of odour observation visualisation with reverse trajectory analysis

4.2 Continuous monitoring of emissions within the facility boundaries

Companies which run odour intensive processes have an own interest to self-monitor the emissions of their site and to understand if, when and where odours might be escaping from their facility boundaries. For other environmental pollutants and hazardous substances this is common practice and often even legally binding. Sensor technologies in this field are proven to be capable and can reliably monitor these pollutants and substances with good accuracy. For odour monitoring however, systems based on gas sensor technology often still lacking accuracy, especially when they are used to determine odour concentrations or to clearly detect and reliably distinguish different odours. Böker (2014) describes various reasons for this in his publication 'On enose methodology'. The most relevant one is the fundamental difference in how the human perception of odours works compared to the way a gas sensor works. Even though there are still some methodical shortcomings and technical challenges to overcome in sensor-supported odour monitoring, the sensor signals may still provide additional useful information for the odour management process, which, combined with other information can help to better understand and evaluate the odour situation. A combination of specifically trained and optimised fenceline odorant monitors with local weather data and the ability to record odour observations reported by internal staff for example, can provide a good foundation to benefit from the 24/7 monitoring capabilities of sensors while also maintaining the ability to factor in the human sensory perception which is ultimately what odour monitoring is trying to achieve. Internal odour observations can also be used to cross check and validate whether the sensor signal output correlates with the human odour perception at the sensor location. In cases where also the emission sources are supposed to be continuously monitored for odour concentration, regular olfactometry of odour samples taken at certain process conditions can be used to cross check whether the results of the sensor monitoring provide comparable results to the olfactometric analysis of the odour samples.

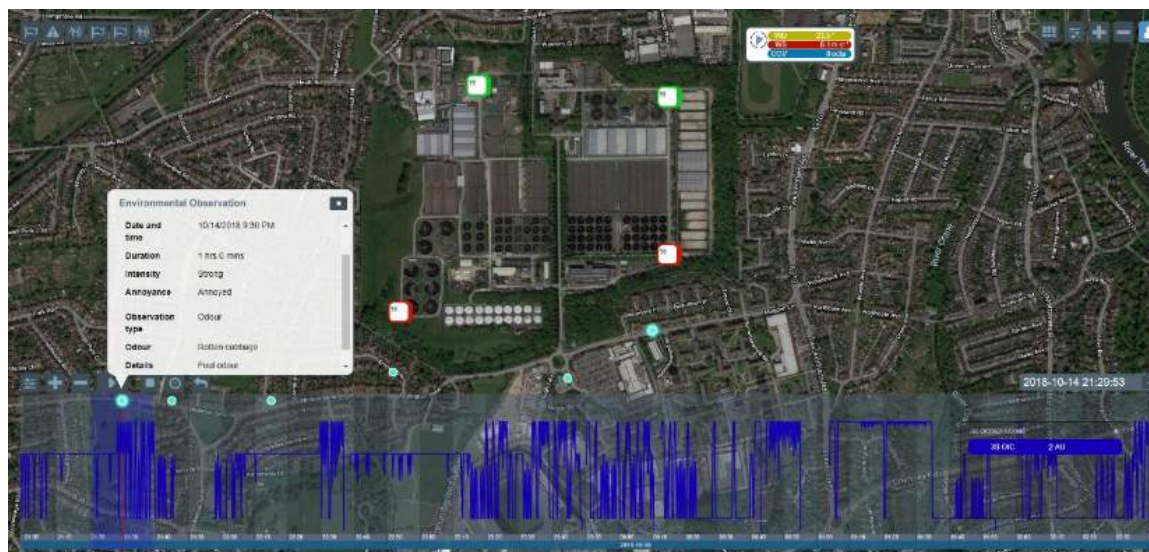


Figure 2: Example of combined data feeds from odorant sensor signals, local weather data and odour observations

4.3 Odour impact forecasting and pro-active process management

Companies which are running odour intensive processes in close proximity to neighbourhoods will inevitably cause odour impacts from time to time when meteorological conditions are unfavourable. Pro-actively avoiding odour impacts based on forecasted odour impact modelling is possible when process conditions can be changed to reduce odour impact. This can, for example, be achieved by increasing the amount of odour mitigating chemicals in wastewater treatment processes, reducing pumping speeds of pipes transporting odorous substances in the petrochemical industry or temporarily activating additional filter systems. If the process conditions cannot be changed to reduce odour concentration on the emission side, a process might still be shifted to a different time when the meteorological conditions are more favourable to avoid impacts on the community. In cases in which neither is possible, a forecasted odour impact can still be used to pro-actively and transparently inform communities about the likeliness of an odour impact. While this might seem counter-productive at first sight, it is important to understand that a transparent and open communication not only shows respect for the concerns of the communities but helps to build trust, which in return, increases the acceptance of odour impacts when they actually occur. Furthermore, the knowledge that odour will occur makes it usually more tolerable than unexpected odour exposure.

Combining forecasted weather data with dispersion modelling based on the actual process schedule and associated emission rates can help in such scenarios to better understand potential future impacts and to provide a basis to pro-actively take actions. Streamlining the registration of odour complaints through the same system further allows to use the generated odour dispersion results to retrospectively validate complaints received against the output of the modelling.

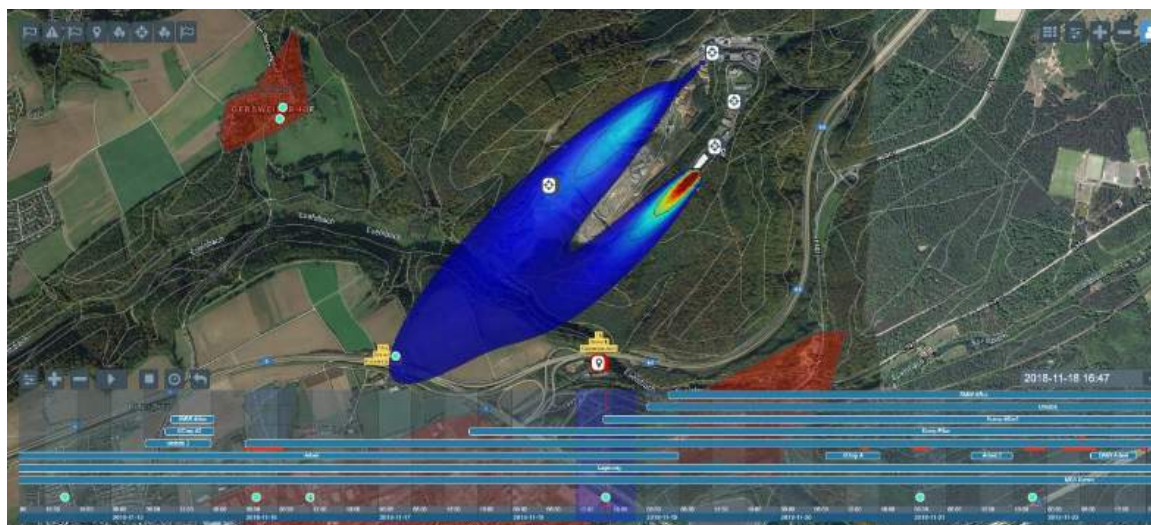


Figure 3: Example of odour dispersion modelling combined with process schedule information and odour observations

4.4 Determining the individual contribution of odour relevant industries in complex industrial areas

Complex industrial cluster areas can cause a multitude of different odour impacts on surrounding neighbourhoods. The total odour impact on the community can be significant in these cases. It is therefore important for municipalities and regulators alike to understand which of the industries contributes how much to the total odour impact to support them in imposing regulations on the biggest contributors. While for some industries the odour characters are easily distinguishable, others are more difficult to clearly differentiate. In this scenario the human perception is even more important as sensors cannot reliably detect and distinguish a variety of unknown odours as the sensors need to be carefully selected, trained and tested to monitor specific odours beforehand. In order to generate statistically representative results, the analysis of the monitoring area needs to be carried out for a longer period, ideally a full year to cover winter and summer times alike.

A combination of grid inspections, carried out by an independent, trained odour panel together with recording of community complaints as well as local weather data can provide the benefit of having objective inspection results which provide scheduled spot checks combined with event based actual impacts perceived by the community. As the location of odour sources and their individual characters are usually known or at least assumed when planning grid measurements, the results of community observations can be validated and cross-checked against weather data and location of potential odour sources in the same manner as the results of the trained odour panel are validated. Statistical analysis of data can then provide a complete picture of the overall as well as the independent contribution on the odour impact.



Figure 4: Example of visualisation of field inspection results (Grid Method) in combination with odour observations.

5. Streamlining of odour related data and stakeholder-specific information distribution

The ability to streamline odour related data from different data sources in a centralised system is essential to provide an individual, goal-oriented solution. Having all odour impact-related information available in one place makes it possible to put data sources in relation to another thus enabling users to cross-check data sets and gain detailed insights into potential cause and effect relations. Continuous access to this information provides the basis for timely solution-oriented actions to be taken to minimise the odour impact. The goal hereby is, to get a clear understanding of what is happening at any given moment concerning odour impact.

Odour monitoring can only be one aspect of a truly holistic odour management process. It is important to understand that, especially for a complex environmental parameter such as odour, human sensory data should be collected and taken into account. Unlike for noise, dust or air pollution, a monitoring system relying on sensor monitoring alone will almost always be insufficient to reflect the actual odour impact. The human sensory data can be provided either by internal staff, citizen observations or independent trained panels of qualified odour assessors. By combining the continuous monitoring capabilities of sensor technology with the human sensory data, the shortcomings of sensor technology can be overcome.

Managing information on odour impact not only serves internal purposes to improve processes and report on odour related incidents. In many cases external parties are also supposed to receive odour impact-related information that is relevant for them. This can be authorities, municipalities, external odour consultants and odour laboratories as well as communities. Therefore, also the communication process with different stakeholder groups should be taken into account in a holistic odour management process. Providing communities, regulators, authorities and affected municipalities with relevant information is an aspect, which is still too often neglected in odour management. To facilitate this communication process, tools should be provided to support companies in this respect. These tools can range from flexible reporting

functionalities to integrated communication portals allowing for a 1:1 communication with affected citizens to follow-up their odour complaints and to provide feedback on the complaint validation process or actions taken.

With the Ortelium Web Platform Olfasense has developed a solution which addresses the needs for a holistic odour management solution through a flexible modular structure in which, case-by-case, required data channels can be integrated to provide a tailored solution to address the defined odour management goals.

6. Conclusions

With a large variety of methods and technologies available to support odour management processes it becomes important to align the methods and technologies used with the associated goals of each individual process and the specific use-case. This requires that software solutions supporting the odour management processes are flexible enough to integrate and streamline data from many heterogeneous data sources. The ability to provide a tailored solution for an individual client scenario ensures to achieve the associated goals with the best efficiency, while keeping the costs of ownership limited to what is actually needed. In addition to streamlining and cross-referencing odour related data for analysis and process optimisation purposes, efficient information distribution to different stakeholder groups plays an important role in a holistic odour management process which addresses all aspects from data collection, processing and analysis to reporting and distribution.

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