CHEMICAL ENGINEERING TRANSACTIONS Volume 23, 2010
Editor Renato Del Rosso

 ISBN 978-88-95608-14-3 ISSN 1974-9791
DOI: 10.3303/CET1023031

Evaluation of electronic noses for online control of odour emissions from sewer systems

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The Berliner Wasserbetriebe are challenged with odour problems from the sewer network of various natures. But only abatement strategies which are adapted to the characteristic discharge conditions lead to an effective odour management. Based on the current situation in Berlin the scope is to identify certain needs in the field of sewer odour management which need to be addressed to tackle odour problems more efficiently. A pool of instruments is available to quantify and characterise odour problems. Solutions for continuous monitoring of odour as a parameter [e.g. ou/m³] however are limited in current applications. Tests of electronic noses for this purpose under realistic conditions seem justified to assess their possibilities in sewer odour management. A large-scale sewer research plant is available in Berlin which will be subject of investigations.

1. Introduction

Continuous extensions of sewer networks and a decrease in water consumption have led to elevated odour emissions arising from sewer networks. Longer retention times, slow flow velocities, depositions of pollutants and hence, the development of anaerobic conditions promote the formation of odour emissions. Together with growing public concern over odours from wastewater treatment works, these phenomena have led to increasing numbers of odour complaints in urban catchments (Stuetz and Frechen, 2001; ATV-DVWK-M 154, 2003; Barjenbruch, 2003). A rise in air temperature due to climate change could additionally enhance microbiological activities and the formation of anaerobic conditions in the sewer.
The Berliner Wasserbetriebe, serving 3,6 Mio inhabitants, are amongst the largest water supply and wastewater disposal companies in Europe. They are challenged to tackle various kinds of odour problems emerging from the sewer network. Critical factors for the location of Berlin are the drop in water consumption by ~20 % in the last 30 years and the very low decline of the channels which is an unfavourable topographic situation for odour formation. Furthermore, Möller and Burgschweiger (2008) predicted an enhanced introduction of sulphate into the drinking water from mining until 2040 in

Please cite this article as: Schwarzbock T., Waschnewski J., Frey M., Rouault P. and Gnirss R., (2010), Evaluation of electronic noses for online control of odour emissions from sewer systems, Chemical Engineering Transactions, 23, 183-188
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certain waterworks in Berlin (up to 260 m/l SO_4^{-2}). This would increase the base load of sulphate in the sewerage and could foster the sulphide production (Frey, 2008).
The Berliner Wasserbetriebe annually spend almost 3 Mio € to reduce odour emissions from the Berlin sewer system (BWB, 2006). Different odour abatement technologies are deployed, which include:

- Constructional measures: e.g. conversion of gravity duct to pressure pipe
- Dosage of additives (liquid phase):
  - Preventing anaerobic conditions: e.g. dosing of calcium nitrate
  - Bonding of hydrogen sulphide by precipitation: e.g. addition of iron hydroxide sludge from water works or iron salts
- Local air treatment: shaft filters (biofilter or hybrid filter using activated carbon)
- Masking/Neutralisation of odours: insertion of gel-plates in manhole constructions
- Operational measures: e.g. flushing of channels

However, the applied measures are often not adequately planned beforehand and/or controlled. A lack of information on the composition of the odour emissions often results in adopting H_2S as single key parameter. These factors can easily lead to inefficiency and only short-term success as also other highly odorous substances like sulphides, amines or aldehydes can be constituents of the sewer air (Frey, 2008).

2. Analysis of needs and tools in sewer odour management

In order to identify target-oriented focal points for Berlin's future sewer management, a functional analysis was carried out. Aim was to find potential comprehensive solutions for a more economic and efficient application of measures, especially regarding dosing rates of additives and planning. Against the background of the local problem within the Berlin sewer network, the main needs in sewer odour management were summarised (main points see Table 1). The emphasis of the analysis was put on point 1 – 4. The goal was to find possible solutions for the fulfilment of these needs which would allow for a more economic and efficient application of abatement technologies.

Table 1: Defined main needs in the field of odour management in sewer networks, based on experience in Berlin.

	Need	Description
1	**Planning measures**	Identification of type of odour problem in order to support planning/designing of abatement strategies
2	**Real-time control**	Real-time control of additive dosing rates
3	**Supervision**	Supervision and documentation of indirect dischargers
4	**Efficiency control**	Documentation of effect/efficiency of measures
5	**Legal compliance**	Documentation of compliance with legal standards
6	**Complaint management**	Complaint management and communication between interest groups (e.g. citizens) and sewer operator
7	**Early warning**	Early warning of odour breakthrough

The main findings of the functional analysis are summarised in Figure 1. Different measures and available tools which could support sewer operators were collected and correlated to certain application fields (like real-time control, documentation, complaint management etc). As illustrated in Figure 1, problems (needs) such as a lack of control of preventive measures can be overcome by applying certain measures like the characterization or quantification of odour problems. The measures in turn rely on the selection of tools (see Figure 1). A pool of technical tools is available which can support certain measures as stand alone instrument or in synergistic coaction. For the characterization of odour problems and the investigation of causes a comprehensive complaint database, together with a cadastre of dischargers would give qualitative information. In combination with analytical instruments which support the measurement of surrogate parameters (like sulphide) or odorous concentrations (using olfactometry), also the intensity of the odour can be determined. This would, for instance, support an expedient planning of measures.

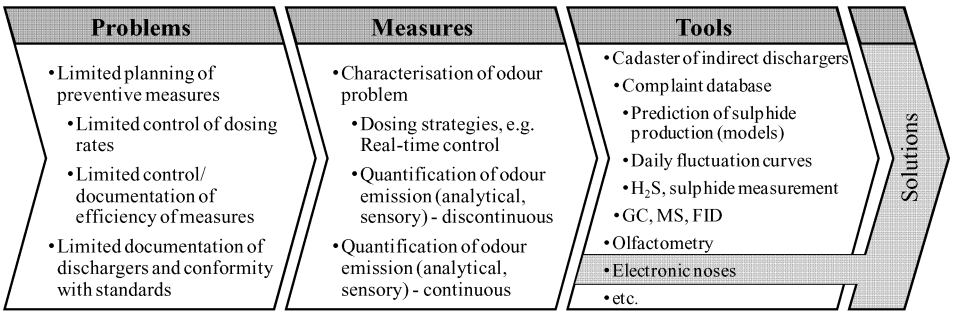

Figure 1: Main findings of the functional analysis of the needs (here designated as problems) identified in sewer odour management.

The drawback of the collected tools at the current technological status is the unavailability of dynamic data which are directly related to the odour (with the exception of sulphide/H_2S measurement). In-sewer processes though are manifold and complex and call for continuous appraisal. For the application of real-time control of additive dosing rates and for continuously documenting legal compliance and dischargers as possible odour causers, online odour measurements especially provide capabilities to fulfil the needs. A selective measurement of gas components such as hydrogen sulphide or the detection of every single air constituent e.g. by gas chromatography were detected as potential instruments, they however do not consider the odour perception or interaction of odorants in the gas complex and can be very cost-intensive.

Measurements by chemo-sensory systems, so called electronic noses combine the potentials: online-ability and quantification of the collective odour impression. After a training phase using olfactometric analysis and a deliberately selected statistical analysis of the signals, electronic noses have the potential to continuously deliver information on the odour situation in the sewer. They therefore were detected as promising tools to be

utilised to achieve comprehensive targets of sewer operators, such as economic and efficient dosing rates or the supervision of dischargers.

3. Electronic noses as tool for sewer odour management

Electronic noses have been identified to have high potential to provide continuous data acquisition and to support the main needs in sewer odour management. They have recently become available for environmental monitoring and have drawn attention due to their ability to determine the odorous concentration in a continuous and collective mode. Figure 2 shows the key abilities of electronic noses which cannot be provided by other tools as a whole. These abilities promise utilisation within sewer odour management to be successful in fulfilling the most important targets of sewer operators (see Figure 2). However, up to now there's a lack of experience under realistic conditions. Manufacturers are challenged with difficulties such as cross-sensitivity towards odourless substances (e.g. methane, oxygen), high sensitivity towards change in temperature and humidity or low long-term stability (Heining, 1998; Boeker, 2007). The time-intensive calibration with olfactometry inherits a high degree of uncertainty of measurement and calls for a deliberate data handling and quality management. In addition no standard procedure for operation and interpretation is available on the market yet and a high level of expertise is necessary for the accomplishment of measurements. However, further developments and investigations regarding their effectiveness or applicability can prove electronic noses as valuable instruments to reach the targets of sewer operators (Figure 2).

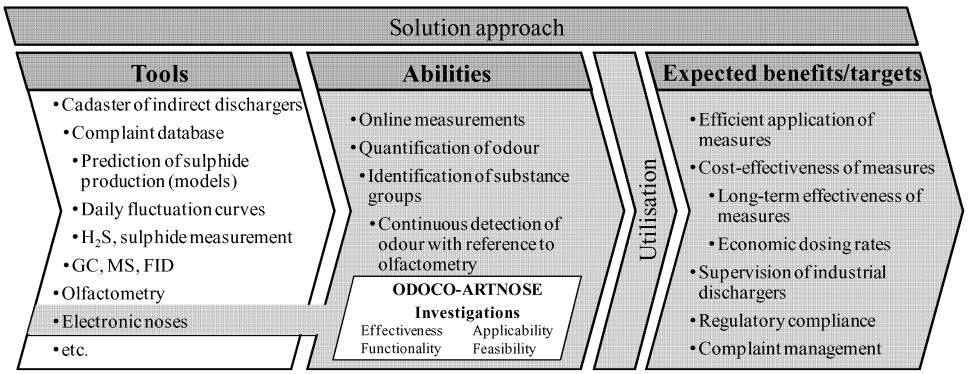

Figure 2: Analytical solution approach for the application of electronic noses: Key abilities, which are to be investigated for the utilisation in sewer odour management in order to reach the targets of sewer operators.

4. Investigations on electronic noses

4.1 Objectives of the investigations

Based on the needs and correlated targets of sewer operators as stated in Figure 2, the objectives are to identify the current technological status and to evaluate the abilities of electronic noses to fulfil the needs in current sewer odour management. This will be

subject of the project ODOCO-ARTNOSE at the KompetenzZentrum Wasser Berlin (water research centre) in cooperation with Berliner Wasserbetriebe and Veolia Water. The online-ability of different available chemosensor arrays will be assessed in order to specify future odour control services based on the application of e-noses in sewer networks. Together with a cost-benefit-analysis the investigations will elucidate the practicability for sewer operators. The outcome of the project will be subject of future investment decisions of the Berliner Wasserbetriebe in odour management.

4.2 Description of the investigations and methods

Electronic noses will be tested at a large-scale sewer research plant under defined boundary conditions. The research plant was constructed by the Berliner Wasserbetriebe to investigate different odour and corrosion strategies. Wastewater from Berlin can be pumped directly from the sewer into two independent gravity lines. A pressure release at the inlet, together with a baffle provides turbulence to strip out odorous gases. The system allows for generating various milieu conditions (e.g. retention time, flow rate) and provides possibilities for diverse structural modifications.

Commercially available electronic noses based on different sensor types (e.g. metal oxide semiconductors, quartz micro balances) will be selected to be tested by following a predefined measurement program. A planning phase will allow to deliberately define the test conditions, such as the arrangement of measurement systems, the duration of tests and test scenarios. It is aimed on testing the e-nose systems under different realistic conditions by imposing variations in the composition of the wastewater and in retention times. Accompanying to the e-nose systems, parameters in liquid and gas phase will be measured simultaneously for process control, namely O_2, COD_{eq}, pH, ORP, H_2S.

4.3 Evaluation methodology

For the different e-nose systems a multi-criteria decision analysis will be elaborated. Following possible non-monetary aspects will be considered, e.g.:

- Effectiveness: quality of data (correlation coefficient, prognosability), response rapidity, measuring accuracy, reliability, measuring range
- Functionality: sensitivity towards humidity, temperature, air pressure, sample preparation, response time, stability (drift), durability, sensitivity in trace amounts, measurement interval
- Applicability: selectivity (odorous/odourless gases), cross-sensitivity, variability
- Practicability: handling, maintenance, calibration, instability in sewers, robustness, economic, operating utilities

The results are nondimensional usability values for each e-nose system (alternatives). The ranking of the alternatives will takes place via determination of the total values.

5. Summary

Different odour abatement technologies are widely-used, but often only as a response after consumer complaints and do not consider adequate identification of odour problems beforehand. An operational approach together with a scientific background is necessary in order to apply effective measures. Continuous odour monitoring solutions have been identified as essential tools to support the whole odour control procedure in sewer networks. This procedure comprises identification and argumentation of odour

origins, planning of abatement measures, control of dosages and the efficiency thereof, to the documentation of the whole process and, as the case maybe, demonstration of legal compliance. Electronic noses have recently become available for environmental monitoring and have a high potential to reduce economic and operational risks for sewer operators in odour management. Different available electronic nose systems will be subject of a test series within a large-scale sewer research plant in Berlin in order to identify future odour control services in sewer networks with special perspective on the current challenges within the Berlin sewer network.

References

ATV-DVWK-M 154 ,2003, Geruchsemissionen aus Entwässerungssystemen-Vermeidung oder Verminderung. ATV-DVWK-Regelwerk. Merkblatt (bulletin) of the German Association for Water, Wastewater and Waste (DWA).

Barjenbruch M., 2003: Prevention of odour emergence in sewage networks. Water Science and Technologies, vol. 47 (7-8), 357 – 363.

Boeker P., 2007, Technisch-sensorische Geruchsmessung (Elektronische Nasen) in der Anwendung. VDI-Reports 1995. Commission on Air Pollution Prevention of VDI and DIN. Symposium, Bad Kissingen, Germany, November 2007.

BWB – Berliner Wasserbetriebe, 2006, Eisen, Salz, Wasser oder Gel gegen Kanalgeruch. Report of Berliner Wasserbetriebe in „Flaschenpost August 2006“ of BWB. Available at: http://www.bwb.de/content/language1/downloads/Flaschenpost_2.pdf. Last accessed: 14.04.2010

Frey M., 2008, Untersuchungen zur Sulfidbildung und zur Effizienz der Geruchsminimierung durch Zugabe von Additiven in Abwasserkanalisationen. Published as part of the series of the Department of Sanitary and Environmental Engineering, University of Kassel, Nr. 28. Kassel.

Heining K., 1998, Elektronische Olfaktometer – Ein Überblick. VDI-Reports 1373. Commission on Air Pollution Prevention of VDI and DIN. Symposium, Bad Kissingen, Germany, March 1998.

Möller K., Burgschweiger J. (Eds.), 2008, Wasserversorgungskonzept für Berlin und für das von den BWB versorgte Umland (Entwicklung bis 2040). Ordering party: Berliner Wasserbetriebe. Berlin.

Stuetz R., Frechen F.-B., 2001, Odours in wastewater treatment: measurement, modelling and control. IWA Publishing, London.