Sewer odour abatement monitoring – an Australian survey
Eric Sivret and Richard M. Stuetz

ABSTRACT
Odourous emissions from sewer networks can significantly impact a local population causing odour annoyance. A survey of nine Australian wastewater utilities that serve over 8.4 million people and operate over 59,000 km of sewer networks was undertaken to summarise the current monitoring practices in Australia with the view to assist the water industry to further improve their practices in operating and monitoring sewer odour abatement systems. Results indicated that most odour abatement systems were monitored through complaints from the surrounding community, H2S is the dominant online and offline monitoring parameter and that a variety of different H2S instruments are used across the industry but the reported use is dominated by two manufacturers. The monitoring data were primarily used for decision making and diagnosis, and there was limited use of non-H2S odourant analysis. The water industry had several significant limitations in terms of its inability to provide gas flow data, process monitoring and complaint data as well as being able to link process monitoring data with maintenance information for instrumentation. The improved collection and management of this data would yield benefits to the water industry in terms of odour abatement design, performance and management.

Key words | odour abatement processes, odour measurement, odours, sewer systems

INTRODUCTION

The complex nature of sewer odours provides many challenges with regards to the monitoring and control of these emissions (Gutierrez et al. 2010; Ganigue et al. 2011), particularly in the design and operation of odour abatement processes (Apgar et al. 2008). The importance of managing odourous emissions from sewers has become more significant in the past 10–20 years, mainly due to the increasing number of complaints and the reported failures in the performance of odour abatement systems (Apgar et al. 2008). The emission of odours present in the liquid phase of a sewer system is mainly dependent on two factors: (i) the physical–chemical circumstances such as turbulence and size of interface, and (ii) amount of odourants present in the liquid phase due to microbial transformation of the wastewater into hydrogen sulphide (H2S) and volatile organic compounds (VOCs) due to sulphate reduction and fermentation processing during sewage transport (Stuetz & Frechen 2001; Hvitved-Jacobsen 2002).

Traditionally, odour management of emissions from sewer systems and wastewater treatment plants (WWTPs) has been maintained by: (i) the use of buffer distances between odourous sources and local receptors (Gostelow et al. 2004), (ii) through the dispersion of emissions through ventilation stacks (Gostelow et al. 2001), and (iii) the use of chemical dosing (such as ferrous and ferric salts, oxygen and sodium hydroxide) to the wastewater to prevent anaerobic conditions and thus control odours and hydrogen sulfide (H2S) formation (Gutierrez et al. 2008; Jiang et al. 2009; Mohanakrishnan et al. 2009). However, with increasing odours complaints about sewer networks and WWTPs and pressure on the use of land surrounding sewer ventilation points, pumping stations and WWTPs, the installation of odour abatement processes (such as activated carbon, biofilters, biotrickling filters and chemical scrubbers) has become a necessary odour management strategy in order to manage the emissions of odours to an acceptable level to limit receptor impact.

The measurement of odourous emissions is usually assessed either as: (i) odour concentrations (OU) by dilution olfactometry via national standards, (ii) by the chemical analysis of the odourous compounds such as H2S and/or VOCs and volatile organic sulphur compounds (VOSCs)
using analytical instruments such as online H₂S monitors and gas chromatography coupled with mass spectrometry (GC-MS), or (iii) by sensory-instrumental analysis of odours using a non-specific sensor array such as electronic noses (eNOSE) (Gostelow et al. 2001; Capelli et al. 2008; Ras et al. 2008; Lebrero et al. 2011).

Sensory measurements use a panel of human sniffers to characterise odours in terms of their perceived effect but give no information regarding composition, whereas analytical measurements characterise odours in terms of their chemical composition but give little information as to their perceived effect of the odour on a receptor; eNOSE based systems mimic the functions of human olfaction using an array of partially selective sensors giving a characteristic pattern for each odourous mixture (Capelli et al. 2008; Muñoz et al. 2010). Presently, there is no effective online instrumental system to replace sensory monitoring, as most online and portable chemical-based instrumentation monitor for particular compounds, such as H₂S (Sohn et al. 2009; Muñoz et al. 2010). These systems are unable to continuously monitor for unknown odourous compounds that vary over time and between emission sources. Additionally, it is often very difficult (if at all possible) to establish a direct correlation between the instrumental results and human perception and to be able to detect threshold concentrations at less than ppt levels of some odourous compounds (Gostelow et al. 2001).

To understand the current water industry practices used for odour monitoring of sewer odour abatement processes, a survey of nine Australian wastewater utilities was undertaken in 2009. The survey aimed to provide the necessary baseline information on the types of online and offline instrumentation, sensory assessments and complaint data that were being collected by the industry. These practices will be discussed in the context of improving the design, management and operating performance of odour abatement systems used to control the emission of odours from sewer networks. Questions for future research are also raised.

MATERIAL AND METHODS

The participating industry partners serve over 8.4 million people and operate over 59,000 km of sewer networks, representing a major portion of the Australian wastewater industry. Understanding the existing industry practices with regards to odour assessment of abatement processes will enable the identification of key knowledge gaps and enable improvement to current management practices and ongoing research efforts within the wastewater utilities, research institutions and instrument manufacturers.

The survey was composed of two sub-surveys (one on odour abatement processes used by industry partners and the second on odour monitoring practices used to assess the performance of odour abatement systems). The surveys were completed by industry partners between June and October 2009. The data from the surveys were collected by the UNSW Odour Laboratory and merged into a database to allow information extraction, and the terminology used by the respondents was standardised to facilitate analysis. Analysis focused on extracting trends, although the depth of the analysis was sometimes limited by gaps within the dataset. It should be noted that these surveys only included monitoring practices on odour abatement processes treating emissions from sewer networks, and not those installed at WWTPs.

RESULTS AND DISCUSSION

A wide range of process monitoring options exist, from online and offline instrumentation, to sensory assessment and community complaint data, along with combinations thereof. An overview of sewer odour abatement monitoring practices employed by the industry partners is shown in Figure 1. Online monitoring was reported for 20.1% of existing odour abatement processes, offline monitoring for 26% of processes, and 5.9% of the processes were completely unmonitored. 59.3% of the odour abatement processes were reported as being solely monitored through complaints from the surrounding community, reflective of a ‘set and forget’ approach to monitoring by the industry partners.

<table>
<thead>
<tr>
<th>Legend</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Online</td>
<td>59.3%</td>
</tr>
<tr>
<td>Online and Offline</td>
<td>12.3%</td>
</tr>
<tr>
<td>Offline</td>
<td>6.4%</td>
</tr>
<tr>
<td>Offline and Sensory</td>
<td>13.7%</td>
</tr>
<tr>
<td>Complaints</td>
<td>5.9%</td>
</tr>
<tr>
<td>None</td>
<td>1.5%</td>
</tr>
<tr>
<td>No Response</td>
<td>1.0%</td>
</tr>
</tbody>
</table>

Figure 1 | Overview of sewer odour abatement monitoring practices in Australia.
The high response rate (98.5%) for types of sewer odour abatement monitoring employed enable further analysis of monitoring (versus process type). Adsorption-based processes showed that these systems are wholly monitored using odour complaints, whereas biological-based odour abatement processes utilised online and offline process monitoring (Figure 2), which is likely a result of the relative complexity of some of the biological processes and the associated monitoring demands. Process monitoring for biofilters, on the other hand, was similar to adsorption-based processes, primarily through complaints data only. Due to the lack of process sizing data, it was not possible to explore relationships between process size and the level/complexity of process monitoring and instrumentation employed.

Online process monitoring was reported for 20.1% of the sewer odour abatement processes and for nearly all process types. A breakdown of the specific parameters reported as being monitored online is shown in Figure 3. These results are presented as a percentage of total sites where online process monitoring was used. While a range of online monitoring parameters was reported, H2S was the dominant monitoring parameter, used for 87.8% of online monitored processes. This is in line with industry practice in most other jurisdictions, where H2S is also the dominant sewer odour abatement process monitoring parameter. Industry partners also indicated that the dominant use of the online data was for decision making and diagnostic purposes (70.7%), 24.4% did not indicate how the information was being used, and the online process monitoring data were leveraged for process control in only 14.6% of the processes. Of the 35 sites with online H2S monitoring, the instrument manufacturer was not reported for 16 sites (45.7%). A range of instrumentation was reported for four industry partners; however, this information was dominated by one of these industry partners reporting 80.5% (or 11 sites) use of a single H2S manufacturer.

A summary of sewer abatement offline monitoring is shown in Figure 4. Unlike online monitoring, offline sewer odour abatement monitoring was dominated by community complaint information (68.8%). While not an objective monitoring approach it was reported as the primary monitoring technique for two of the industry partners. The dominant offline instrumental-based process monitoring parameter was reported to be H2S, although there is some indication of VOC monitoring at a few sites (but no data have been provided). Overall there was very little response with regards to the use of offline monitoring data (Figure 5), with only 29% of sites having an indicated data use. The dominant uses of offline instrumentation monitoring were once again decision making and diagnosis, and typically complaint data were used in a decision making capacity to initiate maintenance (such as media change) for adsorption processes. With regards to H2S instrumentation, only two manufacturers were reported. These data were entirely based on the responses from two of the industry partners, one reporting one system exclusively, the other reporting other instruments exclusively.

Industry partners also reported on non-process odour/odourant monitoring (in particular, sampling and analysis methodologies and instrumentation). Similar trends to offline monitoring conducted for odour abatement processes were observed, indicating that the primary use of H2S

Figure 2 | Biological sewer odour abatement process monitoring.
monitoring was for characterisation and diagnostic purposes, with very little assessment of non-H$_2$S odourants being conducted. Sampling was generally done from a single point (assumed to be representative of the general flow); however, no significant sampling and analysis methodologies (or methodologies specified by external providers) were indicated, with only industry partner reporting Standard Operating Procedures for sample collection and analysis.

Industry partners also reported the use of a single instrument manufacturer for their H$_2$S monitoring, and most indicated the instruments had a high level of reliability when maintained in accordance with manufacturer specifications (including 6 monthly factory calibration). Given the high level of use of H$_2$S instruments (both for odour abatement monitoring and non-process monitoring purposes) and the known impacts of other sulphur compounds in terms of sensor cross sensitivities and interferences (Muñoz et al. 2010), it would be very beneficial for the industry to further evaluate H$_2$S instrument performance with regards to sensor interferences and cross sensitivities.

Some industry partners also reported the use of external service providers to conduct testing (primarily odour and H$_2$S sampling/analysis, with one partner also conducting VOCs and VOSCs analysis). No details were provided with regards to sample storage/transport protocols.
(standard operating practices) used for odour or process monitoring. Industry partners also indicated that additional odour/odourant monitoring is being conducted outside of sewer abatement monitoring; however, only one partner provided data.

The industry partners also reported on gas flow rates through sewer odour abatement systems, as this information is needed for the effective design of odour treatment systems. The survey showed that only 22.1% of the processes are able to report the flow through the abatement process, indicating a significant failure in the ability of industry partners to design odour abatement processes. While it would be expected that providing flow data for passively ventilated sites would be problematic (indeed only 11.6% of passively ventilated sites had flows reported), a high response rate was expected for the forced ventilated sites where fans are operated as these data should be readily available. However, flow data were only provided for a minority (38.8%) of forced ventilated sites. Generally, adsorption processes were reported to be supplied via passive ventilation, along with a few of the lower maintenance types of biological processes (biofilters), whereas the more technologically complex and controlled biological processes (such as biotrickling filters and bioscrubbers) were supplied through forced ventilation. Additionally, a large proportion of the activated carbon systems were also supplied using forced ventilation. The greater use of passive ventilation for adsorption processes and biofilters again most likely reflects the lower maintenance needs and better suitability for application at small, distributed sites, which are typically found in sewer networks.

CONCLUSIONS

Understanding existing water industry practices for odour assessment of sewer odour abatement processes and identifying key knowledge gaps will enable improvements in the management and design of sewer odour abatement processes, therefore reducing complaints from such environmental annoyances. A survey of nine Australian wastewater utilities indicated that: (i) many odour abatement processes are being monitored solely through community complaints; (ii) H2S is the dominant online and offline odour abatement process monitoring parameter and the only monitoring parameter directly related to odours; (iii) significant variability in online H2S monitoring instruments are used across the industry; (iv) low level of process controls are being used in the water industry, but given the dominant types of monitoring processes this is to be expected; (v) H2S is the dominant non-process monitoring parameter (although significant odour monitoring was reported); (vi) reports of non-H2S odourant analysis (VOCs and VOSCs) are limited; and (vii) most sites are maintained in some form, but most are not being routinely maintained.

The water industry had significant limitations in its ability to provide operational and process data (such as gas flows through processes, process monitoring and/or complaint data) as well cross-reference this technical information (i.e. operational vs maintenance of instrumentation). While it is most likely that some of these data does exist within the industry partners, it does not appear to be readily accessible for use in day-to-day decision making,
planning, abatement process design and selection for sewer odour abatement systems. If additional effort could be applied to develop these knowledge gaps (in terms of instrument benchmarking, standardisation, enhancing data collection, storage and availability), the practical benefits to the industry would be improved tracking of performance, design parameters and operating costs and maintenance requirements. This would potentially result in cost saving in terms of capital and operating costs for the installation and maintenance of odour abatement systems.

ACKNOWLEDGEMENTS

This work was supported by the Australian Research Council Linkage Project LP0882016 (with industry support from Barwon Regional Water Corporation, Gold Coast Water, Hunter Water Corporation, Melbourne Water Corporation, South Australia Water, South East Water Limited, Sydney Water Corporation, United Water International, Water Quality Research Australia, and Water Corporation Western Australia).

REFERENCES


First received 6 January 2012; accepted in revised form 16 May 2012