ABSTRACT

Odorous emissions from sewer systems can cause an impact to local communities. A survey of 9 Australian wastewater utilities that serve over 8.4 million people and operate over 59,000 km of sewer networks was undertaken to assess the current management practises used for sewer odour abatement. The survey results indicated that activated carbon based systems are the most common, most processes are passive flow and are maintained in some form, but most are not being routinely maintained and monitored solely through community complaints. Activated carbon media is generally replaced in a reactive manner following failure and the receipt of complaints. H2S is the dominant online and offline monitoring parameter with limited use of non-H2S odorant analysis and low level of process control used in odour abatement. There were significant limitations in the industry’s ability to provide fundamental process data such as process age and flow for processes supplied by forced ventilation, in addition to process design data (design criteria and input characterisation), operating costs data, and process monitoring/complaints data.

INTRODUCTION

Odorous emissions from sewer systems can cause an impact to local communities surrounding such facilities and result in complaints for wastewater utility operators. The generation of odours in sewers is influenced by the organic load of the wastewater being transported through the sewer system. Odorants that are present in the liquid phase of a sewer system are emitted into ambient air wherever there is a liquid-gaseous interface (Hvitved-Jacobsen, 2002) The emission rate is mainly dependent on two factors: (i) the physical-chemical circumstances such as turbulence, size of interface and (ii) amount of odorants present in the liquid phase due to microbial transformation of the wastewater into hydrogen sulfide (H2S) and volatile organic compounds (VOCs) due to sulfate reduction and fermentation processing during the sewage transport.

The importance of managing odorous 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. The increase in sewer odours can be attributed in part to tighter restrictions imposed on the discharging of industrial wastewater to sewers and the demand management practises imposed on communities to reduce drinking water usage. These restrictions have significantly lowered the level of biological toxic metals (lead, chromium, mercury, arsenic, cadmium) in sewage and decreased the volume of wastewater been transported through the sewer networks resulting in increased level of H2S and VOCs in the sewage, which are odorous when transferred from the liquid to sewer air. Additionally, the increased use of household sulfate containing detergents (ii) higher sewage temperatures caused by the increasing use of domestic hot water and (iii) increases in sewer line lengths and thus sewage residence times has also increased the level and complexity of odorous and non-odorous compounds in sewers.

The composition and concentration of sewer odours provides many challenges with regards to the management and control of the emissions from sewer systems, particularly in terms of the design and operations of odour abatement processes used to treat odorous emissions from these facilities. To understand the current industry practices used for odour monitoring of sewer odour abatement processes, a survey of 9 Australian wastewater utilities was undertaken as part of the Australian Research Council (ARC) linkage project on Sewer Corrosion and Odour Research (SCORE). The survey of the participating industry partners (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, and Water Corporation Western Australia) aimed to provide the necessary baseline information to assess the current industry odour assessment and abatement practises for sewer odour management.

METHODOLOGY

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 and abatement will enable the identification of key areas of potential improvement to provide a focus for ongoing research effort within
the SCORE sub-project 3, Odour measurement and assessment, evaluation of odour treatment technologies.

The survey was composed of two sub-surveys (one on odour abatement processes used by industry partners and second on odour monitoring practices used to assess the performance of odour abatement systems). The surveys were completed by industry partners between June to October 2009. The data from the surveys was collected by the UNSW Atmospheric Emissions and 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 odour abatement processes treating emissions from sewer networks, and not those installed at wastewater treatment plants.

RESULTS

ODOUR ABATEMENT SURVEY

The survey reported that 204 odour abatement processes are being operated by the industry partners at 187 sites (some sites had multiple processes operating in parallel). The odour abatement processes been operated (Figure 1) consisted of adsorption based processes such as activated carbon and zeolite based filters were dominant (76.5%), followed by biological processes (21.1%). In general, there was a similar distribution of odour abatement processes across all of the industry partners, although some used more biological processes than others, and one utility used adsorption based processes (zeolite filters). The large number of adsorption based processes is most likely due to distributed nature of odour abatement unit in sewer networks and the desire for these systems to be low maintenance.

Adsorption based processes were dominated by two process types, zeolite filters and activated carbon filters. Activated carbon filters were employed by most of the industry partners, except for one industry partner that only used zeolite filters. For biological based processes, biofilters were the dominant process at 44.2% of total biological processes, 62.8% if soil bed filters are included in this number. This likely reflects the less active nature of these processes and the prevalence for smaller, contained processes which are more suitable for distribution to multiple sites and require less ongoing supervision and maintenance than more complex biological odour abatement processes like biotrickling filters and bioscrubbers (32.6% and 4.7% of biological processes, respectively). All of the reported biotrickling filters and bioscrubbers also utilised polishing processes (most commonly activated carbon) to ensure treatment integrity.

Gas supply (type and flow rate) is a fundamental parameter for odour abatement process design and can have a significant influence on process selection and operation. A summary of process feed types is provided in Figure 2. Most processes are treating a passive sewer gas flow with a minority supplied by forced (fan driven) flow. A comparison of feed type (forced or passive ventilation) and process type is shown in Figure 3.

![Figure 1: Odour abatement process types: a) adsorption; b) biological](image1)

![Figure 2: Odour abatement process feed supply type](image2)
Generally, adsorption processes were supplied via passive ventilation, along with a few of the lower maintenance types of biological processes (biofilters). More technologically complex and controlled biological processes (such as biotrickling filters and bioscrubbers) are supplied through forced ventilation, though a large proportion of the reported activated carbon filters are 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.

To enable effective design of odour abatement system, gas flow rates is a fundamental sizing parameter. The survey highlighted are significant failure in the ability of industry partners to design odour abatement processes, with only 22.1% of the processes being able to report the flow through the abatement process. 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 since this data should be readily available. However, flow data was only provided for a minority (38.8%) of forced ventilated sites. A breakdown of reported flow rates is provided in Figure 4 but the sample size (45 processes) is small when spread across individual processes and limits detailed analysis. This lack of fundamental flow data suggests limitations in either data storage or data availability.

The industry survey also requested information on the age of installed odour abatement processes and the performance criteria used to evaluate odour abatement processes. The response for installation information was quite poor, only 33.3% of sites had the process age identified. The use of performance criteria to evaluate odour abatement processes was also poor (Figure 5), with no response been given for over 75% of the installed odour abatement processes and no performance criteria being specified for 19.5% of the processes, leaving only 5.5% of processes being reported to be evaluated against a performance criteria. Additionally, the use of performance guarantees for odour abatement processes installed on sewer networks was limited (reported for only 4.9% of processes). The overall results once again demonstrate significant gaps of the current lack of understanding of specific odorants in sewer emissions.

The industry partners also reported that only 5.4% of the odour abatement processes installed were designed using data supplied by the industry. Survey data showed that no response was provided for 75% of the sites and that no data was provided to the designers for 19.6% of the installed processes. An analysis of the data supplied for the activated carbon based odour abatement processes are summarised in Figure 6. There appears to be a fairly even distribution of the types of data being provided (H₂S, odour, dimethyl sulfide (DMS) and total volatile organic compound concentrations (TVOC)), however, it should be noted that design data was only provided for 10% of the activated carbon based odour abatement processes, all of which were reported by two of the industry partners.

The industry reported a good response rate (84.8%) for the availability of maintenance information, however a low response for the application of routine maintenance programs (Figure 7). As expected there was a very high level of routine maintenance programs reported for the more complex and maintenance demanding process types (biotrickling filters and bioscrubbers) whereas a “set and forget” approach was more commonly applied to many adsorption based odour abatement processes, which are often only.

![Figure 4: Comparison of odour abatement process size and process flow rate for 45 processes only](image-url)
maintained in a reactive manner when there is evidence of a process failure (often by complaints).

The industry data did provide a significant amount of information with regards to media replacement frequency for activated carbon based odour abatement processes. A summary of this data is provided as Figure 8. In general, many (40%) activated carbon based odour abatement processes are operated in a purely reactive manner where media is replaced following evidence of odour breakthrough. A slightly larger number (47.1%) are operated in a more proactive manner with media replacement frequencies ranging from three months up to ten years. Some industry partners also provided information on the identified sources of odour abatement failure events (Figure 9).

The application of process control to odour abatement processes was very limited (3.4% of processes) and restricted to biotrickling filters and bioscrubbers. Very little data was provided with regards to the specific control methodologies applied, i.e. whether off-gas H₂S data is being used as an odour surrogate and process operating parameters are being adjusted to maintain as desired level of removal, or instead (and most likely) if existing process control is purely focused on maintaining specific operating parameters (such as pH or water levels) at the desired settings. Odour abatement process performance data was also requested in the survey. No inlet/outlet H₂S monitoring data or any other performance data was provided by any of the respondents.

**ODOUR MONITORING SURVEY**

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 (Figure 10). Further analysis of monitoring conducted on adsorption based processes showed that these systems are wholly monitored using odour complaints whereas for biological based odour abatement processes utilise online and offline process monitoring 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.

While a range of online monitoring parameters were reported to be used for odour abatement monitoring, H₂S was the dominant monitoring parameter, used for 87.8% of online monitored processes (Figure 11). Industry partners indicated that the dominant use of the online data was for decision making and diagnosis purposes (70.7%), 24.4% did not indicate how the information was being used, and that the online process monitoring data was leveraged for process control in only 14.6% of the processes. Of the 35 sites that reported using online H₂S monitoring, 16 sites (45.7%) could not report the instrument manufacturer, four of industry partners reported using a range of H₂S instrumentation with one of these industry partner reporting 80.5% (or 11 sites) using a single H₂S manufacturer.

Unlike online monitoring, offline process monitoring was dominated by community complaint information (68.8%). While not an instrumentation based (or objective) monitoring approach it was the primary reported process monitoring technique for two of the industry partners. Of offline process monitoring conducted using instrumentation, H₂S was once again the dominant monitoring parameter, although there is some indication of VOC monitoring at a few sites (but no data has been provided). Overall there was very little response with regards to the use of offline monitoring data with only 29% of sites having an indicated data use. The dominant uses of offline instrumentation monitoring were once again decision making and diagnosis. Typically, complaint data was also used in a decision making capacity to
initiate maintenance such as a change in media for adsorption processes.

The survey also requested information on non-process odour/odorant monitoring conducted by the industry partners (in particular sampling and analysis methodologies and instrumentation). The industry partners reported very little assessment of non-H$_2$S odorants supporting that H$_2$S monitoring was the primary monitoring conducted for characterisation and diagnostic purposes of abatement processes. 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 who reported the using process monitoring also reported the use of a one instrument manufacture 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 this instrument type (both for odour abatement process monitoring and non-process monitoring purposes), it could be beneficial to the industry to further evaluate H$_2$S instrument performance with regards to sensor interferences and cross sensitivities. As H$_2$S monitors are known to be impacted by other sulfur compounds in terms of sensor cross sensitivities and interferences (Stuetz and Frechen, 2001).

Three 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 VOC and reduced sulfur compound analysis). No details were provided with regards to sample storage/transport protocols (standard operating practices) used for odour or process monitoring and limited analytical cost data was provided by industry partners.

**CONCLUSION**

A survey of 9 Australian wastewater utilities was undertaken as part of the ARC Sewer Corrosion and Odour Research (SCORe) linkage project to assess the current management practices used to monitoring odour treatment systems for sewer odour abatement. Understanding the existing industry practices with regards to odour assessment and abatement will enable the identification of key areas of potential improvement for the design and operation of sewer odour abatement processes.

Two industry surveys on odour abatement processes and odour monitoring practices were completed between June to October 2009. The data was collected by UNSW 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 limited by gaps within the dataset.

The completed surveys indicated that 204 odour abatement processes are being operated by the industry partners. The odour abatement processes consisted of adsorption based processes, mainly activated carbon and zeolite based filters and biological based processes, mainly biofilters with some biotrickling filters.

The surveys indicated several trends within the industry: (i) activated carbon based odour abatement processes are well distributed across nearly all of the industry partners; (ii) mixture of domestic and mixed sewage odour sources, minimal industrial only sites; (iii) most processes are passive flow; (iv) most sites are maintained in some form, but most are not being routinely maintained; (v) activated carbon media is generally replaced in a reactive manner following failure and the receipt of complaints; (vi) media saturation and moisture impacts are the dominant sources of odour abatement process failure, with other reported failures primarily mechanical in nature; (vii) many processes are being monitored solely through community complaints; (viii) H$_2$S is the dominant online and offline odour abatement process monitoring parameter, and the only monitoring parameter directly related to odours; (ix) significant variability in online H$_2$S monitoring instruments used across the industry; (x) low level of process control being used in the industry, but given the dominant types of processes this is to be expected; (xi) H$_2$S is the dominant non-process monitoring parameter (although significant odour monitoring was reported) and (xii) limited reports of non-H$_2$S odorant analysis (VOCs and reduced sulfur compounds).

There were significant limitations in the water industry’s ability to provide fundamental process data such as process age and flow for processes supplied by forced ventilation, in addition to process design data (design criteria and input characterisation), operating costs data, and process monitoring/complaints data. Furthermore, the industry partners were unable to identify the selection/design rationale for existing odour abatement processes, nor provide abatement process monitoring data. While it is most likely that some of this data exists within the industry partners, it does not appear to be centrally stored in a readily accessible manner for use in decision making, planning, or abatement process design and selection for sewer odour abatement.
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REFERENCES


Figure 3: Odour abatement process type by feed type (forced or passive ventilation)

Figure 5: The use of odour abatement process design performance criteria in all abatement processes and activated carbon only

Figure 6: Data provided to designers for activated carbon odour abatement processes (n=70).
Figure 8: Media replacement frequency for activated carbon odour abatement processes only

Figure 9: Reported sources of odour abatement process failure

Figure 11: Online monitoring parameters