Summary Report

SP3: Odour measurement and assessment, evaluation of odour treatment technologies

1. Background

Gas phase samples are often collected from operating sewerage systems during investigations intended to improve odour management. However, there is limited systematic evaluation of alternate sampling protocols. Likewise, there is limited systematic evaluation of the capacity of odour management technologies to reduce the concentration of specific odorous substances. The objective of SP3, *Odour measurement and assessment, evaluation of odour treatment technologies*, is to address these limitations by:

- Identification of those substances likely to be the major cause of odour in sewer gases.

- Evaluation of methods for storage and analysis of field samples intended for odour analysis. Two approaches are evaluated – storage of gas samples and storage of liquid samples.

- Measuring the performance of activated carbon (AC) filters, biofilters and biotrickling filters by determining the removal efficiency of a number of specific odorous substances.

2. Identification of odorous substances

2.1 Test sites and sampling arrangements

Gas samples were collected in Nalophan bags over a 12 month period from 18 sewer network sites in Sydney and Melbourne. The sampling interval was 2 weeks over summer and 1 month for the rest of the year. The sites included a range of sewage types (ie domestic, domestic and commercial, domestic and trade waste) and a range of sewer arrangements including gravity sewers and rising mains. Chemical addition for odour abatement was in use upstream of some of the sites.

2.2 Sample analysis

The analytical approach assumed that the substances most likely to be the principal contributor to odour levels in sewer gases were all volatile sulphur compounds (VSC's). The concentration of a range of typical VSC's in the collected gas samples was determined by gas chromatography. A description of steps taken to evaluate the reliability of the gas analysis methodology is included as Appendix 1.

2.3 Results

The results for the most abundant VSC's are summarised in Table 1. The most obvious features of the data in this table are:

- The high abundance of hydrogen sulphide compared to other substances.

- The most prevalent organic sulphur compounds were MeSH and DMS. VSC's other than those listed in the table were present at trivial concentrations.

- The standard deviation of all data is small compared to the range. This indicates the presence of 'outliers' in the data set.

Table 1. Summary of observed concentrations (µg/m3) of a number of VSC's in gas samples from a number of sewers in Sydney and Melbourne

VSC[1]	Sydney				Melbourne			
	Range	Mean	Standard deviation	%[2]	Range	Mean	Standard deviation	%[2]
H_2S	2.5 to 55,000	4,400	590	83	6 to 21,000	1990	260	63
MeSH	1.8 to 9,960	675	86	14	2.8 to 11,400	1420	160	31
DMS	<DL[3] to 500	39	4	0.9	0.9 to 840	94	10	2
CS_2	<DL to 341	18	3	0.4	<DL to 146	20	2	0.5
DMDS	<DL to 69	8	0.8	0.2	<DL to 525	50	7	1.3
DMTS	<DL to 80	10	0.7	0.2	<DL to 561	35	5	0.9

Notes

[1]H_2S: hydrogen sulphide, MeSH: methyl sulphide, DMS: dimethyl sulphide, CS_2: carbon disulphide, DMDS: dimethyl disulphide, DMTS: dimethyl trisulphide.

[2]'%' is the percentage abundance based on the observed mean concentration.

[3]The detection limit, DL, was in the range 0 to 2 µg/m3 depending on the substance.

2.4 Seasonal variability

A feature of the data was the large seasonal variability. Thus, the total concentration of the VSC's listed in Table 1 typically varied by a factor of 10 depending on the season. The highest concentrations were generally observed in August/September and in February to April. Low concentrations were observed in December and January. The reason for this variability is unclear but it does suggest that data obtained by sampling during December and January should not be regarded as indicative unless validated by a more extensive sampling program.

A more detailed description of this work is available in Wang et al (2014).

3. Storage of gas phase samples prior to VSC analysis

3.1 Test methods

The experimental approach was based on the premise that gas phase samples would be collected and stored in flexible bags prior to analysis for VSC's only. Gas phase samples intended for analysis of volatile organic compounds (VOC's) such as benzene, toluene etc are expected to be collected in sorbent tubes because of concern about the effect of the background level of VOC's in sample bags.

Testing to determine the preferred approach to storage of gas samples for VSC analysis comprised two phases – a laboratory based program and a field based program.

3.2 Laboratory based test program

3.2.1 Description

The main features of the laboratory based test program were as following:

1. Bag material

The program involved evaluating the suitability of sample bags prepared from Tedlar (polyvinyl fluoride), Mylar (biaxially orientated polyethylene terephthalate) and Nalophan (polyethylene terephthalate).

2. Sample preparation

The bags were filled with air and then dosed with the sulphur compounds listed in Table 2. These compounds were selected because they are commonly encountered in field samples and are readily available as stable standards.

Table 2. Sulphur compounds

Family	Compound	In bag concentration ($\mu g/m^3$)	Odour threshold ($\mu g/m^3$)
Inorganic	Hydrogen sulphide (H_2S)	98	0.2 to 270
Thiols	Methyl sulphide (MeSH)	254	0.0003 to 38
	Ethyl sulphide (EtSH)	157	0.046 to 21
	2 methyl 2 propane thiol	150	0.09 to 3.3
	1 butane thiol	158	1.5 to 3.0
Sulphides	Dimethyl sulphide (DMS)	159	0.3 to 160
	Ethyl methyl sulphide (EMS)	158	62
	Dimethyl disulphide (DMDS)	196	1.1 to 78
	Diethyl disulphide (DEDS)	186	0.3 to 230
	Dimethyl trisulphide (DMTS)	225	06 to 7.5

3.   Factors investigated

The experimental program involved investigating the effect on the composition of the stored gas of:

- Storage time up to 66 hours

- Storage temperatures of 5°C, 20°C and 30°C

- Sample relative humidity based on dosing the bags with a suitable aliquot of water

- Exposure to indoor light during storage

- Exposure to a range of VOC's based on dosing the bags with a number of VOC's.

4.   Analytical methods

Gas samples were withdrawn from the bags at intervals and analysed for all of the VSC's listed in Table 2. The effect of the storage conditions on VSC concentrations was evaluated partly by determining the relative recovery of each substance (RR). An RR value of 100% indicates that there has been no reduction in the concentration of the particular VSC during storage.

The standard deviations of all the RR values obtained by analysing each gas sample, STDRR, were also determined. A small standard deviation indicates that the composition of the gas stored in the bag was stable over the test period.

3.2.2 Results

The main features of the results are:

5.   Effect of bag material

The effect of bag material was assessed by pooling all RR values for each material after a storage time of 66 hours (i.e. all values of RR after 66 hours irrespective of storage temperature, sample relative humidity, exposure to light or the presence of VOC's) and determining the proportion of these values greater than 80%. Typical outcomes are summarised in Table 3. The data in this table suggests that:

- The performance of all 3 materials is similar for all substances other than hydrogen sulphide.

- The recovery rate for hydrogen sulphide is higher for Tedlar than for other materials.

Table 3. Percentage of RR values greater than 80% after 66 hours of storage

Bag material	Proportion of RR values greater than 80%					
	H_2S and thiols			Sulphides		
	H_2S	MeSH	EtSH	DMS	DMDS	DMTS
Tedlar	59%	64%	68%	97%	100%	43%
Mylar	42%	62%	71%	97%	100%	50%
Nalophan	39%	66%	73%	98%	100%	46%

6.   Effect of storage time and temperature

Data concerning the effect of storage time and storage temperature on values of RR for a number of substances is summarised in Table 4. The main implications of the data in Table 4 are:

- There is evidence that RR values decrease at temperatures above 20°C.

- RR values generally decrease with storage time and a period less than 24 hours appears to be advisable.

Table 4. : Effect of storage time and temperature on RR values for typical substances

Substance	T (°C)	Bag material					
		Tedlar (%)		Mylar (%)		Nalophan (%)	
		18 h	36 h	18 h	36 h	18 h	36 h
H_2S	5	89	84	92	68	81	57
	20	93	81	90	63	88	59
	30	83	75	81	58	83	60
MeSH	5	97	93	99	93	100	94
	20	100	88	100	89	100	90
	30	96	74	97	75	100	84
EtSH	5	100	95	100	97	100	98
	20	100	93	100	97	100	95
	30	94	74	97	80	100	87
DMTS	5	92	75	92	68	89	61
	20	82	58	97	73	94	69
	30	72	50	97	75	96	71

7.   Effect of relative humidity

Data concerning the effect of relative humidity (RH) on RR values during sample storage are provided in Table 5. The data generally indicates that RR values are lower when samples are stored at 0% relative humidity and a humidity level around 40% is advisable to minimise changes in concentration during sample storage. This conclusion is supported by STDRR data which showed that lower values were obtained at RH values of 40%.

Table 5. Effect of relative humidity on RR values for typical substances

Substance	RH (%)	Bag material					
		Tedlar (%)		Mylar (%)		Nalophan (%)	
		18 h	36 h	18 h	36 h	18 h	36 h
H$_2$S	0	79	66	81	58	72	49
	40	97	92	93	67	89	63
	80	89	83	89	65	90	64
MeSH	0	96	77	97	82	100	86
	40	100	94	100	92	100	93
	80	97	85	99	83	100	89
EtSH	0	97	80	100	88	100	89
	40	100	95	100	96	100	98
	80	97	87	97	90	100	93
DMTS	0	76	58	93	70	90	65
	40	89	65	99	73	99	73
	80	81	61	94	73	90	63

8. Effect of exposure to indoor light

The effect of exposure to light during sample storage on RR values for some typical substances is summarised in Table 6. The data shows no clear relationship between RR values and the presence of light during storage. However, values of STDRR are generally lower for samples stored in the dark and this practice is recommended.

Table 6. Effect of exposure to indoor light on RR values for typical substances

Substance	Light (%)	Bag material					
		Tedlar (%)		Mylar (%)		Nalophan (%)	
		18 h	36 h	18 h	36 h	18 h	36 h
H$_2$S	0	84	74	85	65	82	59
	100	93	86	90	61	85	58
MeSH	0	97	83	98	85	100	87
	100	98	88	99	86	100	92
EtSH	0	99	86	100	90	100	91
	100	97	89	98	92	100	95
DMTS	0	86	67	96	78	83	83
	100	78	55	94	66	79	79

3.2.3 Effect of exposure to VOC's

The effect of VOC's on RR values for some typical substances is summarised in Table 7. The data is this table indicates:

- RR values for hydrogen sulphide are lower in the presence of VOC's. This result occurs for all 3 bag materials and is more pronounced at higher storage times.

- RR values for the 3 organic sulphides are lower in the presence of VOC's if the samples are stored in Tedlar bags. This is particularly the case for storage times greater than 18 hours.

- There is some evidence that the effect of VOC's is reduced if the samples are stored in Mylar or Nalophan bags.

Table 7. Effect of VOC's on RR values for typical substances

Substance	VOC dose (%)	Bag material					
		Tedlar (%)		Mylar (%)		Nalophan (%)	
		18 h	36 h	18 h	36 h	18 h	36 h
H_2S	0	94	92	94	71	90	67
	100	82	68	82	56	78	50
MeSH	0	100	93	99	89	100	94
	100	95	77	98	82	100	84
EtSH	0	100	93	98	92	100	95
	100	96	81	100	90	100	91
DMTS	0	94	76	95	78	93	73
	100	70	46	95	66	94	61

3.2.4 Recommendation

The recommended sample storage arrangements arising from the laboratory study are:

- Use of Tedlar bags for sample collection and storage. Nalophan and Mylar are acceptable lower cost alternatives.

- Storage times should be kept to a minimum and a period of 24 hours is a recommended practical limit.

- Samples should be stored at temperatures around 20°C.

- Sample storage at 40% relative humidity is preferred but it is generally impractical to control this variable.

- Samples can be stored in indoor light but exposure to direct sunlight is not recommended.

- The presence of VOC's can be expected to influence results but this factor is difficult to control.

3.3 Field based test program

3.3.1 Description

The field based test program involved collecting gas phase samples from 2 sites in operating sewers. The samples were collected in Tedlar bags and stored at 20 C under dark conditions. Initial testing was performed at the time of sample collection and subsequently after a range of storage times.

3.3.2 Results

Relative recovery data is included in Table 8. The main implications are that likely RR values using the recommended storage arrangements are in the range:

- 75% to 110% for hydrogen sulphide after 24 hours
- 85% to 130% for a number of typical VSC's.

Odour concentration data determined by dynamic olfactometry is presented in Table 9. This data indicates that sample storage for up to 24 hours has a limited impact on odour concentration measurements.

Further details of this work are available in Hung et al (2014).

Table 8. RR values for typical substances based on field samples

Site/ Sample	Relative recovery RR (%)									
	H_2S		MeSH		DMS		DMDS		DMTS	
	18 h	24 h	18 h	24 h	18 h	24 h	18 h	24 h	18 h	24 h
1 - 1	-	107	-	87	-	92	-	129	-	95
1 - 2	103	103	90	93	91	95	113	112	105	108
2 - 1	75	75	87	88	-	-	-	-	-	-

Table 9. Odour concentration RR values in field samples

Site/Sample	Time (h)	RR (%)
1 - 1	24	95
	48	87
2 - 1	24	99
	48	74

4. Storage of liquid samples from the field. Evaluation of the Odour Emission Ability (OEA) method

4.1 Description of OEA method

Collection of gas phase samples in the field is complex and the OEA method relies on collection of a liquid sample. The key aspects of the technique are:

- The field sample is liquid sewage which is transported to a laboratory for analysis.

- Gas samples are prepared in the laboratory by evaporation of a known liquid volume (typically 100 to 200 µL) into a sample bag filled with a suitable gas, usually nitrogen or clean air.

- The gas phase samples are then analysed in the laboratory in the normal manner.

The laboratory test results can be used to determine the maximum possible mass of odour or odourant that could be emitted from the liquid phase. Thus, the method does not provide a measure of actual gas phase odour levels in the field but it can be used, for example, to determine the effectiveness of liquid phase odour reduction technologies.

The laboratory based analysis of gas phase samples can determine either an odour concentration, OU, using dynamic olfactory or a concentration of a specific substance, C. The odour emission ability (OEA) of the liquid can be calculated using the following equation:

$$OEA = OU.V_G / V_L$$

where V_G is the volume of gas in the sample bag and V_L is the volume of liquid evaporated into the sample bag.

In a similar manner, the compound emission ability (CEA) of the liquid can be calculated from:

$$CEA = C.V_G / V_L$$

4.2 Method validation

The experimental program focussed on:

- Development of an appropriate method for injecting the liquid sample into the sample bag and

- Validation of the method under laboratory and field conditions.

4.2.1 Evaluation of liquid injection techniques

9. Description

Two alternate injection techniques were evaluated. In the first case, the liquid sample was progressively injected into the gas stream upstream of the sample bag. The objective of this dynamic injection method was to evaporate all liquid prior to the gas stream entering the

sample bag. An alternate static injection method was based on adding a liquid sample directly to the sample bag and allowing evaporation to take place in situ.

The suitability of the two injection techniques was evaluated using two VSC's, dimethyl trisulphide (DMTS) and bismethylthiomethane (BMTM). These substances were selected because they are stable and water samples containing a known mass of each were prepared and added to Tedlar sample bags using the two alternate techniques. The samples were then stored for a period (20 C and 45% RH) and the gas phase subsequently analysed by gas chromatography to determine RR values for each substance. Some of the static injection method samples were stored at elevated temperatures to encourage evaporation.

10. Results

The injection evaluation results are listed in Table 10. The main implications are:

- Recovery rates for DMTS are similar for both the dynamic and static methods if the gas sample is stored under laboratory conditions. This is not the case for BMTM where RR values for the static method were around 70% under laboratory conditions.

- The use of elevated temperatures to encourage evaporation in the static method causes a reduction in RR values.

The general conclusion is that the dynamic injection method is preferable.

Table 10. Recovery rates, RR (%), for several VSC's

Test	DMTS				BMTM	
	Dynamic[1]	Static			Dynamic[1]	Static[2]
		Lab[2]	50 C[3]	75 C[4]		
1	99	109	86	44	100	62
2	103	111	91	54	106	69
3	110		92	51	99	72
4	101		91		107	71
5	108		88		108	75

[1]Stored for 30 minutes at 20°C and 45% RH.
[2]Stored for 60 minutes at 22°C and 45% RH.
[3]Stored for 30 minutes at 50°C and 20% RH.
[4]Stored for 30 minutes at 75°C and 20%RH.

4.2.2 Laboratory validation

11. Description

Validation of the OEA method was based on use of the dynamic injection method to prepare gas phase samples containing a known mass of a number of VSC's and VOC's. The recovery of these substances was then determined by measuring the gas phase concentration using gas chromatography.

In most cases, the tests were based on injection of a liquid sample containing a single substance. However, a separate set of tests based on injecting a liquid sample containing a VOC mixture (i.e. a mixture of butanal, 1- butanol and butanoic acid) and a VSC mixture (ie a mixture of DMDS, DMTS and BMTM) were also undertaken.

A similar set of tests were undertaken using dynamic olfactometry to determine the suitability of the OEA method for assessment of odour.

12.   Results based on concentration measurements

The results of the validation tests based on measuring the RR of specific substances in 5 replicate tests are presented in Table 11. The principal outcomes are:

- The RR values for single substances other than butanoic acid averaged above 95% and had low standard deviations, indicating both good recovery and good reproducibility.

- Recovery rates for individual substances in mixtures were generally 5% to 10% lower than was the case when the substances were added as single components.

Table 11. Laboratory validation of OEA method based on the dynamic injection method

Test type	Number of tests	Substance	Recovery rate RR (%)		
			Range	Average	Std dev
Single substance	5	Dimethyl disulphide (DMDS)	98 - 101	100	1
	5	Dimethyl trisulphide (DMTS)	99 - 110	104	5
	5	Bismethyl thiomethane (BMTM)	100 - 108	104	4
	5	Butanal	81 - 118	97	14
	5	1-Butanol	88 - 120	101	14
	5	Butanoic acid	28 - 78	55	20
VOC mixture	5	Butanal	78 - 116	93	13
		1-Butanol	88 - 109	95	8
		Butanoic acid	43 - 114	76	31
VSC mixture	5	DMDS	89 - 97	92	4
		DMTS	93 - 98	95	2
		BMTM	91 - 97	94	2

13.   Results based on dynamic olfactory measurements

The results based on dynamic olfactory measurements are presented in Figure 1 for the VOC mixture and in Figure 2 for the VSC mixture. These data are based on preparation of a duplicate sample each day for 5 days. The odour concentration in each duplicate sample was then analysed using dynamic olfactrometery.

The results in both Figure 1 and 2 indicate variability in measured OU concentration which is in the range 25% to 30%. Calibration of the odour panel in each case using n-butanol indicated that this trend could not be attributed to any bias in the odour panel.

4.2.3   Field validation

14.   Description

Liquid samples were collected from 2 sewers in the Sydney area. Two samples were collected from each site - a filtered sample and an unfiltered sample.

The liquid samples were refrigerated prior to analysis and sewer headspace samples were also collected at the same time.

15.   Results

The OEA of each liquid sample was assessed by an odour panel at intervals over a 10 day period. The results are shown in Figures 3 and 4 and the change in OEA with storage time is summarised in Table 12. The principal implications are:

- Filtering the liquid samples at the time of sampling reduced the measured OEA by up to 30% and is not recommended.

- OEA results for the unfiltered sample from Site 1 (Figure 3) were typically in the range 40,000 to 50,000 OU/L and were stable over the storage period of 10 days. The gas phase sample from this location had an odour strength of about 5,000 OU/m.

- The results for the unfiltered sample from Site 2 shown in Figure 4 were probably also stable over 10 days, averaging around 60,000 OU/L. Analysis of the gas sample from this site indicated an odour strength of 7,750 OU/m3.

Table 12. OEA data for liquid sewage samples stored under refrigerated conditions

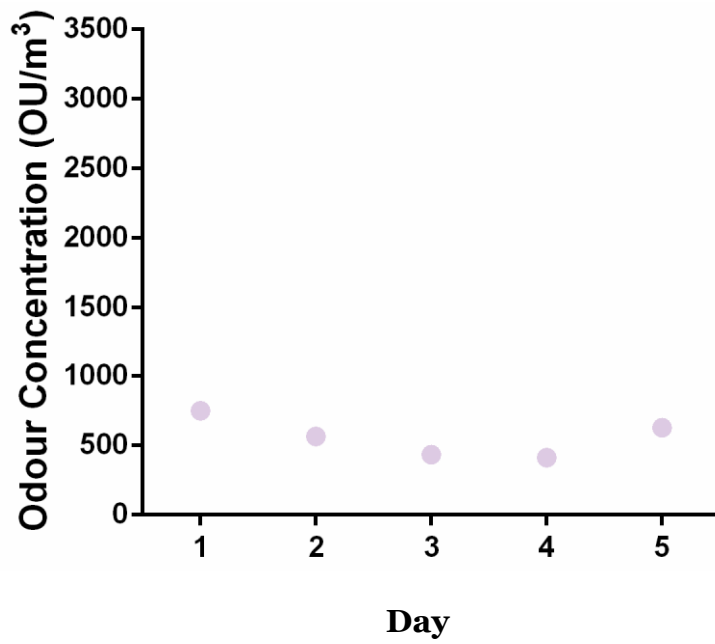| Day	Change in OEA from day 0 (%)			
	Site 1		Site 2	
	Unfiltered	**Filtered**	**Unfiltered**	**Filtered**
1	-13	-31	+16	-16
2	-21	-15	-23	-49
6	-6	-7	-25	-43
10	-3	-15	-25	-53

Figure 1: OEA method: Olfactory measurements of VOC mixture
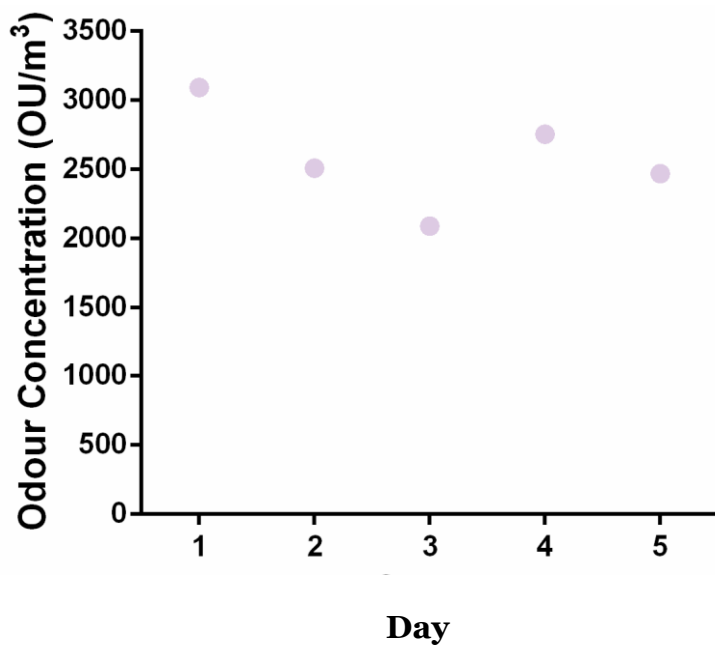

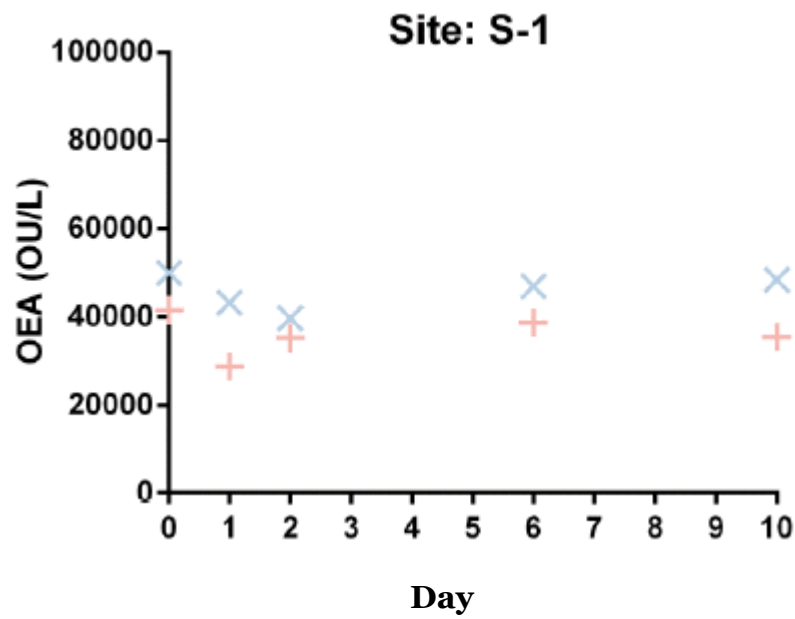*Figure 2: OEA method: Olfactory measurement of VSC mixture*

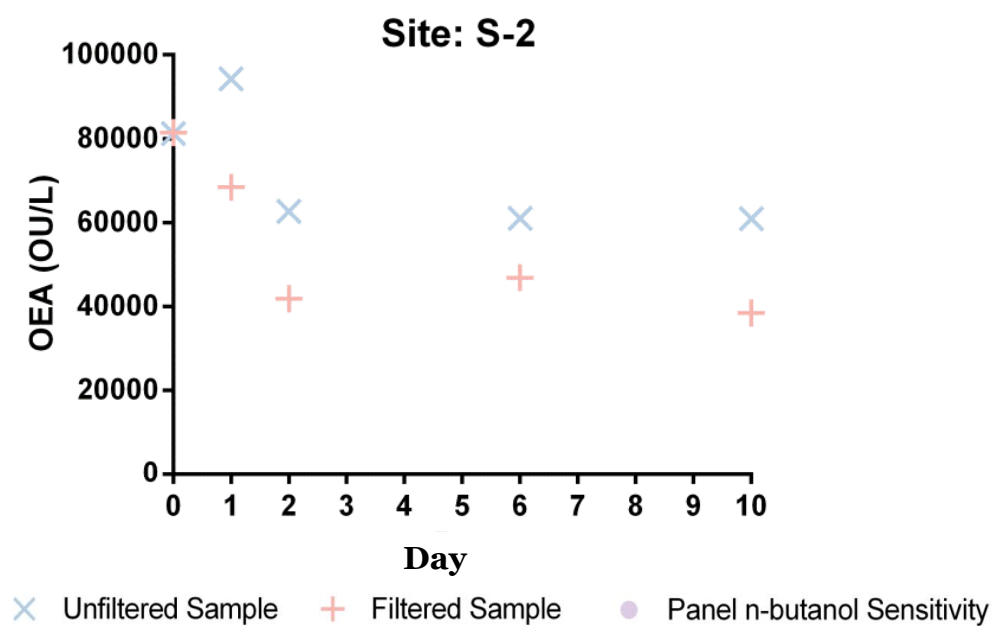*Figure 3: OEA values for liquid sewage samples stored under refrigerated conditions*

Figure 4: OEA values for liquid sewage samples stored under refrigerated conditions

4.2.4 Outcome of laboratory and field validation studies

The general conclusions arising from this investigation of the OEA method are:

- Liquid samples should not be filtered at the time of sampling.

- Liquid samples can be stored for up to 10 days under refrigeration.

- The OEA method overestimates the expected odour levels in the field. This is not unexpected since the method assesses the maximum potential odour generated by the aqueous phase and this is unlikely to be realised in the field due to factors such as limited evaporation of volatile substances into the gas phase and dilution due to ventilation.

4.3 Use of the OEA method to identify key odourants

The capacity of the OEA method to identify the compounds primarily responsible for the odour impact of a gas phase sample from a sewer was evaluated by simultaneously collecting samples of the 2 phases from an operating sewer in the Sydney area. Both samples were analysed for a range of VSC's and VOC's. The analysis of the liquid phase samples was based on the OEA method. The results are summarised in Tables 13 and 14.

Table 13 indicate that the relative abundance of VOC's identified by the OEA method is very different to the relative abundance values determined by analysis of a gas phase sample. The discrepancy is not as marked for VSC's (Table 14) and both methods identified hydrogen sulphide and methyl sulphide as the most abundant sulphur species.

The general conclusion arising from this investigation is that the OEA method is unlikely to be suitable for identifying the full range of odourous substances in an operating sewer.

Table 13. Relative abundance of VOC's identified in simultaneous samples of the gas and liquid phases in an operating sewer

	Gas phase	**Liquid phase**
VOC's arranged in order of decreasing abundance	Trimethyloctane	Undecane
	7- methylpentadecane	Dodecane
	Hexadecane	Benzaldehyde
	Trichloromethane	Toluene
	Toluene	O – xylene
	Tetrachloroethane	Benzene
	o - xylene	Dimethylbenzene

A more detailed description of this work is available in Wang et al *Odour emission ability (OEA), Method development and evaluation, Progress report, August 2014*.

Table 14. Relative abundance of VSC's identified in simultaneous samples of the gas and liquid phases in an operating sewer

	Gas phase	Liquid phase
VSC's arranged in order of decreasing abundance	Hydrogen sulphide	Hydrogen sulphide
	Methyl sulphide (MeSH)	Methyl sulphide (MeSH)
	Dimethyl disulphide (DMDS)	Dimethyl sulphide
	Carbonyl sulphide	
	Dimethyl sulphide	
	Carbon disulphide (CS_2)	
	Dimethyl trisulphide	
	Diethyl disulphide	
	Diethyl disulphide	
	Ethyl sulphide	

5. Performance of activated carbon (AC) filters, biofilters and biotrickling filters

The performance of AC filters, biofilters and biotrickling filters was assessed by obtaining gas phase samples from a number of operating facilities in the field. These 3 technologies were assessed because a survey indicated that they were the most prevalent technologies in use within the Australian water industry to control sewer odours. In the case of the present work:

- A biofilter comprises an irrigated organic bed
- A trickling filter comprises an inert packing with liquid recirculation, pH control and nutrient addition.

The location of the test facilities is summarised in Table 15 and all locations were downstream of substantially domestic catchments.

Table 15. Location of odour treatment test facilities

Technology	Melbourne	Sydney	Perth
AC	3 sites	7 sites	
Biofilters	2 sites	2 sites	1 site
Biotrickiling filters	1 site	1 site	1 site

Gas samples were collected from the inlet and the outlet of the test facilities on a number of occasions over the period between 2010 and 2012. Design and operating conditions were not recorded.

The gas phase samples have been analysed for a range of VOC's and VSC's and the results have been assembled into a database. OU data was not obtained.

The VOC and VSC database will be used to determine the removal efficiency of each compound at each test facility. It is expected that this work will be competed in 2017.

Appendix 1: Summary of development of laboratory techniques for gas phase analysis

The present evaluation of options for odour measurement and assessment and the parallel investigation into the performance of odour treatment technologies relied on reliable techniques for analysis of gas samples for a range of VOC's and VSC's. A report describing this work is available as Sivret et al, *Final report: Analytical methodology development and evaluation*, Progress report to SCORe, December 2012.

The main aspects of this report are:

VOC analysis

- The preferred analytical technique is gas chromatography coupled with a mass spectrometer detector (GC – MS).

- Pure liquid samples were obtained for a range of typical VOC's and laboratory tests conducted to confirm 'linearity' (i.e. the relationship between the mass of the substance in a sample and the total area under the detector response curve) and the limit of detection.

- Linearity was confirmed and the limit of detection ranged between 0.02 and 4.0 µg/m^3, depending on the specific substance. These concentrations are below the odour threshold for all substances included in the test program.

- The reliability of the analytical method for field samples was verified by sampling the gas phase in 2 operating sewers, preparing subsamples and determining the standard deviation in the test results, expressed as a percentage of the mean (ie determining the relative standard deviation, , RSD). The RSD of the field samples was comparable to the RSD of laboratory tests based on analysis of pure samples.

VSC analysis

- The preferred analytical technique is gas chromatography coupled with a sulphur chemiluminesence detector (GC – SCD).

- The test program was similar in concept to that used for VOC's.

- The typical detection limit was 0.2 to 10 µg/m^3 and was generally comparable to the odour threshold for each substance.

- The RSD of field samples was comparable to the RSD of laboratory tests based on analysis of pure samples.

References

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