WITHYHEDGE LANDFILL

AIR QUALITY MONITORING INTERIM SUMMARY REPORT 4

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Executive Summary

This interim report summarises the data gathered from the ongoing monitoring around Withyhdege Landfill. The monitoring now includes diffusion tubes for the assessment of Hydrogen Sulphide and Volatile Organic Compounds (VOCs) that provide averaged concentrations over a defined period and instantaneous measurements of Hydrogen Sulphide using a Jerome analyser. The monitoring programme is primarily aimed at gathering quantitative data to provide lines of evidence to help assess risks from the exposure to off-site air quality.

Comparison of the Hydrogen Sulphide concentrations detected using diffusion tubes with health-based criteria indicates that the concentrations continue to be below the guidance values for intermediate/lifetime exposure.

Monitoring of Volatile Organic Compounds (VOC) has revealed many VOCs to be present at very low levels and below evaluation criteria, where available. This monitoring is to cease.

Using a hand-held instrument, known as a Jerome, Hydrogen Sulphide concentrations have been logged at different locations. Many readings of Hydrogen Sulphide reported by the Jerome analyser during the latest monitoring period are close to or below the detection limit and there are few recorded values above a 5ppb guideline value. It is evident from the repeated use of the instrument at different times of the day over several days that such concentrations are not persistent over such time-frames. At many monitoring positions on different occasions the Jerome did not detect Hydrogen Sulphide above the level of detection.

1 SCOPE

The operator of Withyhedge Landfill is implementing a series of measures agreed with NRW to address odours emanating from the site, including re-profiling, capping and additional landfill gas extraction. Alongside these measures, the operator is funding a scheme of air quality monitoring in the communities surrounding the site and also within the site.

The monitoring programme is primarily aimed at gathering quantitative data to provide lines of evidence to help assess risks from the exposure to off-site air quality that is impacted by the landfill.

This interim report summarises data gathered from the ongoing monitoring. The monitoring now includes diffusion tubes for the assessment of Hydrogen Sulphide and Volatile Organic Compounds (VOCs) that provide averaged concentrations over a defined period and instantaneous measurements of Hydrogen Sulphide using a Jerome analyser.

The concentrations recorded by the diffusion tubes are obtained by laboratory analysis of the tubes. The data reported by the laboratories is shared with the operator, Pembrokeshire Council and NRW.

2 MONITORING

Landfill gas is typically dominated by methane and carbon dioxide. Numerous other compounds may, however, also be present and some of these can be detected as odour. Such compounds are often sulphur based and can include hydrogen sulphide. As hydrogen sulphide can give rise to odour and can be readily measured, it is being used as a surrogate for the potential presence of landfill gas, whilst recognising that there are a wide range of compounds and sources that can also generate odorous compounds like hydrogen sulphide.

To try and better understand what other compounds may also be present, TENAX diffusion tubes designed to allow the analysis of Volatile Organic Compounds are also being used with this monitoring starting 8 March 2024 at the same positions as the Hydrogen Sulphide tubes. This data is presented in this report alongside the Hydrogen Sulphide monitoring which has been ongoing since February 2024.

3 DIFFUSION TUBE MONITORING

3.1 Hydrogen Sulphide Monitoring

Diffusion tubes monitoring Hydrogen Sulphide have been set at ten off-site locations at various compass directions around Withyhedge Landfill with additional tubes on-site, as shown on Figures 3-1 and 3-2. The tubes are positioned to take into account the need for free air movement, safety during maintenance and consideration of potential damage, theft or vandalism. The suitability of the current positions is being reviewed as the programme develops. Details of each position are summarised in Table 3-1.

On 4 June 2024, two additional monitoring positions were added to the network; D11 in Prendergast and D12 in Crundale, as shown on Figure 3-1. The details of each position are included in Table 3-1. In this report, measurements have been made using hand-held instrumentation at these positions and in the next report data from the diffusion tubes will be available.

Table 3-1 Monitoring positions

Figure 4-1 & 4-2 reference	Location Description	Position	Height above ground/m
Community monitoring locations			
D1	Spittal Cross cross-roads west of Spittal	Street furniture at cross-roads	0.6 (old & new positions)
D2	Adjacent Spittal School	Lamp post	2.1
D3	Corner of spring gardens and Castle Rise, Spittal. Adjacent to farm	Lamp post	2.1
D4	Cross-roads of B4329 and Spring Gardens East of Spittal	Street furniture	2
D5	B4329 between Scolton and Bethlehem	Street furniture	2.2
D6	B4329 at Bethlehem	Lamp post	2.2
D7	On road heading west out of Poyston Cross	Lamp post	2.2
D8	Adjacent to properties at Poyston Water	Lamp post	2.1
D9	Rudbaxton Water Bridge	Northern side of bridge	1.2
D10	Adjacent to Junction with A40 near Corner Piece Inn	Lamp post	1.9
D11	Withybush Road, Prendergast	Sign post	1.8
D12	B4329 Crundale near junction with Cross Lane	Sign post	1.8
On-site monitoring locations			
Access ramp (WL1)	Eastern side of access ramp	Metal post	2.1
Fence posts (WL2)	Fence post close to edge of permanent capping	Fence post	1.1
Litter skids (WL3)	Metal post close to edge of permanent capping	Metal post	2.2
Field fence post (WL4)	Fence post west of temporary capping	Fence post	0.9
CCTV tower (WL5)	Metal post south of active Cell 8	Metal post	2.2
IBC cell 8 (WL6)	Metal post west of active Cell 8	Metal post	1.65
Cell 7 IBC corner (WL7)	Metal post south of Cell 7	Metal post	1.9

Figure 3-1 Community monitoring positions D1- D12

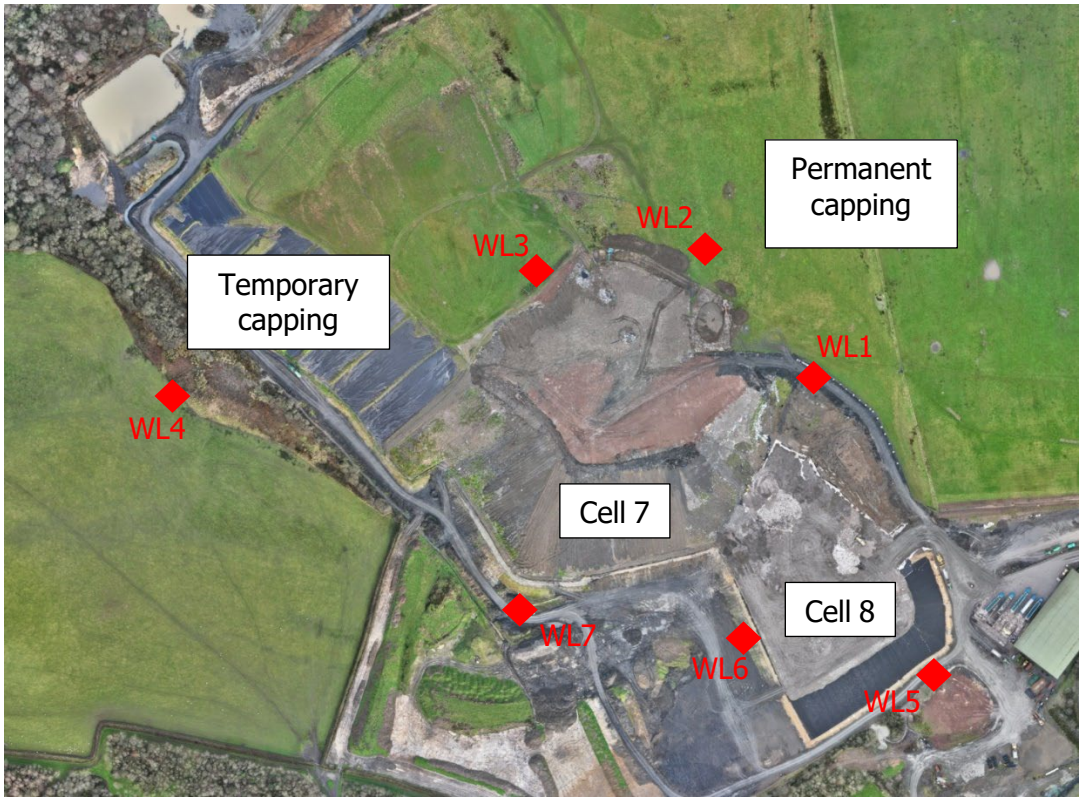


Figure 3-2 On-site monitoring positions

3.1.1 Review of Hydrogen Sulphide Results

The results of the Hydrogen Sulphide diffusion tube monitoring are summarised in Tables 3-2 and 3-3. The original laboratory certificates from the latest monitoring are included in Appendix 1. The term exposure period is used to define the sampling period when air was able to diffuse into the tubes before the tubes were taken down, sealed and returned to the laboratory for analysis. Analysis has been performed at Gradko International which is a UKAS accredited testing laboratory (No. 2187).

Table 3-2 Hydrogen Sulphide results from Community Monitoring Positions

	Exposure Period			
	5 Feb - 1 Mar	1 Mar - 3 Apr	3 Apr - 7 May	7 May - 4 Jun
	H_2S	H_2S	H_2S	H_2S
Location	**ppb**	**ppb**	**ppb**	**ppb**
Laboratory Blank	0.05	0.04	0.05	0.06
Junction west of Spittal - D1	<0.08	Removed	0.12	<0.07
Spittal School - D2	<0.08	<0.06	0.14	<0.07
Spittal - D3	<0.08	<0.06	0.07	<0.07
Upper Scolton - D4	<0.08	<0.06	0.14	<0.07
Scolton Road - D5	<0.08	<0.06	<0.06	<0.07
Bethlehem - D6	<0.08	<0.06	<0.06	<0.07
Poyston Cross - D7	<0.08	<0.06	<0.06	<0.07
Poyston Water - D8	<0.08	<0.06	0.06	0.09
Rudbaxton - D9	0.1	0.07	0.07	0.1
A40 Junction - D10	<0.08	0.07	Removed	<0.07

Table 3-3 On-site Hydrogen Sulphide monitoring results

	Exposure Period			
	8 Feb - 1 Mar	**1 Mar - 3 Apr**	**3 Apr - 7 May**	**7 May - 4 Jun**
	H_2S	**H_2S**	**H_2S**	**H_2S**
Location	**ppb**	**ppb**	**ppb**	**ppb**
Laboratory Blank	0.05	0.04		
Access ramp (WL1)	1.48	Lost		
Fence posts (WL2)	1.82			0.27
Litter skids (WL3)	2.04			
Field fence post (WL4)	0.29	1.38	0.31	0.12
CCTV tower (WL5)	0.6	4.4	9.24	2.16
IBC cell 8 (WL6)	1.04			
Cell 7 IBC corner (WL7)	1.8	6.54	3.97	

During the first exposure period wastes were being removed from the crest of the site, gas wells were being drilled into the waste mass and temporary capping of the west facing flank was in progress. During the second and third exposure periods capping works were continuing and gas extraction extending to newly capped areas. In the latest period, capping works were completed.

Comparison of the concentrations detected using diffusion tubes in the community with the health-based evaluation criteria in Table 3-4 indicates that the concentrations fall below these guidance values for intermediate/lifetime exposure.

Table 3-4 Referenced health based guidance values

	Intermediate exposure criteria (up to 1 year)	**Lifetime exposure criteria**
Hydrogen Sulphide concentration	20 ppb (30 µg/m^3)	1 ppb (2 µg/m^3)

Values taken from references 1 and 2

Higher concentrations of hydrogen sulphide have been reported from the tubes exposed on site. These concentrations are below the workplace exposure limit of 5000 ppb for an 8-hour time-weighted average reference period (Ref 3).

3.2 Volatile Organic Compound Monitoring

Monitoring of Volatile Organic Compounds (VOC) in air using diffusion tubes commenced on 8 March 2024. The diffusion tubes used for this monitoring are called TENAX tubes and were provided by the same laboratory providing the Hydrogen Sulphide tube analysis. These tubes were positioned alongside the Hydrogen Sulphide tubes and work in the same way i.e. during the exposure period air is free to circulate into the tube and at the end of the period the tube is sealed and returned to the laboratory for analysis.

The reader should be aware that the wooden posts holding the tubes at D9 Rudbaxton Bridge appear to have been recently stained. It is not precisely known when this work was done or the nature of the product used but it was sometime after 21 March based on review of photographs. Such wood stains can potentially contain and release VOCs to the air.

3.2.1 Review of VOC Results

Volatile organic compounds (VOCs) are a complex variety of chemical substances. Like Hydrogen Sulphide, they may be generated and released by a variety of natural processes and human activities. This large group of compounds is defined on the basis of their ability to exist as a vapour. Common examples include the recognisable odour associated with paint and petrol, the smell detectable from air fresheners and the smell of freshly cut grass – all these smells are due to the presence of a range of different VOCs, some of which produce a detectable odour.

The VOC laboratory certificate is presented in Appendix 2. Each of the tubes were analysed for the top 20 VOCs found to be present following full-scans on previous tubes. Readers will note that the certificate spans several pages and includes tables of data from each of the different monitoring positions. To aid understanding, visualisation and assessment of this data the concentration data expressed in units of microg/m^3 (micro grammes per cubic meter of air) has been extracted from the last column of the certificate and repeated in Table 3-5 which spans several pages. This same data is also graphically presented as a series of charts following the table.

To the right-hand side of the monitoring data in Table 3-5 are criteria used to assess air quality. These come from a range of sources and are intended to provide an initial yardstick against which the reader can better appreciate the levels reported from the diffusion tubes. It is evident from this comparison that the concentration levels estimated from the tubes are lower than these criteria, where values have currently been found to be available.

Coupled with review of the charts it is evident that:

- the VOCs reported continue to be found at low levels just above the level of detection in many cases
- Some compounds are detected at higher concentration off-site compared to the tubes located on-site, and vice versa

Given the current low levels detected, the intention is for future monitoring to focus on only Hydrogen Sulphide monitoring.

Table 3-5 Results from VOC Diffusion Tubes (continues over several pages)

	Community Positions										On-site positions			Evaluation Criteria
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	WL2	WL4	WL5	EAL & EA Study 2010
.beta.-D-Glucopyranose, 1,6-anhydro-												5.7		
1,2-Benzenedicarboxylic acid			2.1	66	50									
1,4-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester			44			64				49	40	100	16	
1,4-diazabicyclo[4.3.0]nonan-2,5-dione, 3-methyl												9.0		
1-Butanol					0.5									
1-Hexanol, 2-ethyl-	0.8	2.1	1.4	0.8	1.2	0.6	1.0	2.1	0.9	1.2	0.9		1.1	570
2-Furanmethanol												2.8		
2-Phenacyl-quinoxaline						4.5		5.4		8.6	8.9			
5,10-Diethoxy-2,3,7,8-tetrahydro-1H,6H-dipyrrolo [1,2-a:1',2'-d]pyrazine												12		
9H-Fluorene, 9-methylene-									5.5					
Acetamide												1.9		
Acetic acid	0.4	0.5	0.8	0.4	0.3	0.4	0.3	0.5	0.3	0.5		3.7	0.6	3700
Acetophenone**	1.4	1.0	1.9	2.4	1.5	2.0	2.0	2.2	1.2	2.6	2.4	2.9	0.8	
Benzaldehyde**	1.6	1.6	2.3	2.2	1.9	2.1	1.9	2.3	1.5	2.6	2.3	3.1	1.3	350
Benzamide, N,N-dimethyl-		1.1												
Benzene	0.3		1.8				0.2		0.4	0.7		3.8		5/30
Benzene, isocyanato-													1.9	
Benzeneacetaldehyde**							0.3							
Benzenecarbothioic acid	0.7		1.1	1.8	0.8	1.5	1.3	1.3	0.6	2.2	2.1			
Benzenesulfonamide, N-butyl-				1.4										
Benzoic acid	7.7	3.0	14	19	7.0	14	14	15	6.1	22	24	25	1.2	
Benzothiazole		2.6	1.1	0.5				0.9	0.6					
Benzoylformic acid			1.1	1.6		1.2	1.4	1.4		2.1	1.9			
Cyclohexane, isothiocyanato-		2.6												
Cyclopentasiloxane, decamethyl-	1.2						1.4		2.0		3.0		3.2	
Cyclotetrasiloxane, octamethyl-	1.5		2.4	1.7	2.6	1.9	1.4	2.1	1.7		2.4		4.9	
Cyclotrisiloxane, hexamethyl-	3.3	3.3	5.0	3.2	5.5	3.8	2.1	3.7	3.2	3.2	3.9	4.8	12	
Cycluron		1.6												
Decanal**					0.7		0.4			1.0				
Diethyl Phthalate						1.1		2.5					17	
Diphenyl sulfide					1.4									
Dodecanal**													1.3	
Dodecane, 2,6,10-trimethyl-		3.0												

	Community Positions										On-site positions			Evaluation Criteria
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	WL2	WL4	WL5	EAL & EA Study 2010
Eicosane					32				6.6					
Fluoranthene									1.4					
Glycerin												3.6		
Heptadecane, 9-hexyl-												21		
Hexadecane		3.3												
Hexanal**	0.2	1.0											0.5	
l-Pyrrolid-2-one, N-carbamoyl-												7.0		
N,N-Dimethylaminoethanol												7.0		
Naphthalene								1.6						3
Nonadecane, 9-methyl-				28		11					104			
Nonanal**	2.1	20	2.2	2.1	2.9	0.6	1.4	3.0	2.5	7.7	3.7		4.6	
Nonanoic acid	0.4		1.0	0.6			0.6		0.7	1.6	1.0			
Octadecane				10		2.9					30			
Octadecane, 2-methyl-													93	
Octanal**	<0.3	1.2			0.6								1.0	
o-Hydroxybiphenyl								4.8						
Pentacosane			12		8.8			4.2		4.5		81		
Pentadecane		10												
Phenol	0.5	0.8	0.7	0.7	0.6	0.7	0.7	1.0	0.7	0.8	0.9		2.4	200/3900
Phenol, 4-(1,1-dimethylpropyl)-													1.0	
Phenylmaleic anhydride	2.2	1.5	3.7	5.1	2.1	4.0	4.2	3.9	2.2	5.7	5.5			
Phthalic anhydride	0.4					0.8	0.4							
Pyridine												1.9		
Pyrrolo[1,2-a]pyrazine-1,4-dione, hexahydro-												4.5		
Silanediol, dimethyl-	0.5				0.5	0.5	0.3	0.6	0.5	0.6			1.2	
Tetracosane			4.7	47						7.3	96	9.3	90	
Tetradecane		2.4												
Tetrahydrofuran	0.2													3000/59000

NOTES
** Compounds may be an artefact due to reaction of ozone with Tenax sorbent.
Compounds with a quality match below 85% are noted as a tentative identity and shown in italics. These compounds are outside of the scope of laboratory UKAS accreditation.
Wooden posts at D9 Rudbaxton Bridge appear to have been recently stained. It is not precisely known when this work was done but it was not before 21 March 2024 based on review of photographs.

Evaluation Criteria:
EAL / EA 2010 – Environmental Assessment Level. EALs represent a pollutant concentration in ambient air at which no appreciable risks or minimal risks to human health are expected.
EAL values taken from Air emissions risk assessment for your environmental permit available on gov.uk and EA 2010 values from Environment Agency Report: P1-396/R Table 5.2.

Chart 3-1 VOC's at D1

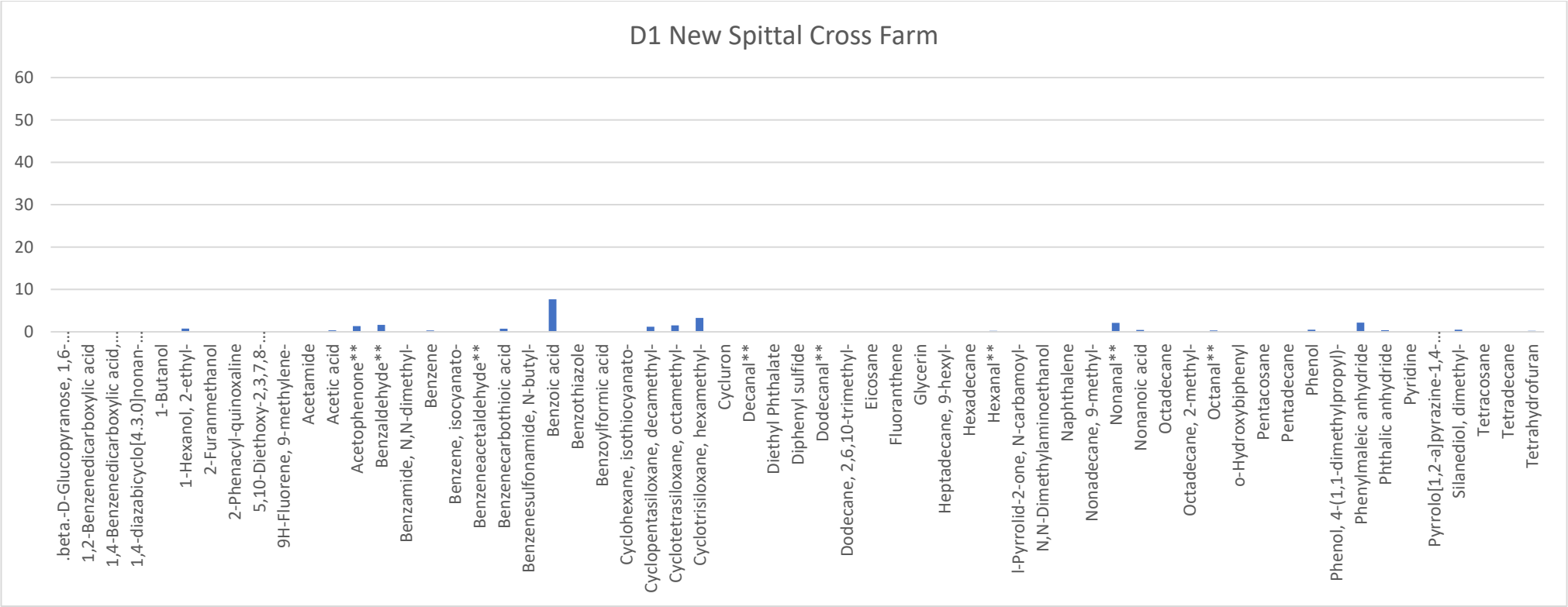


Chart 3-2 VOC's at D2

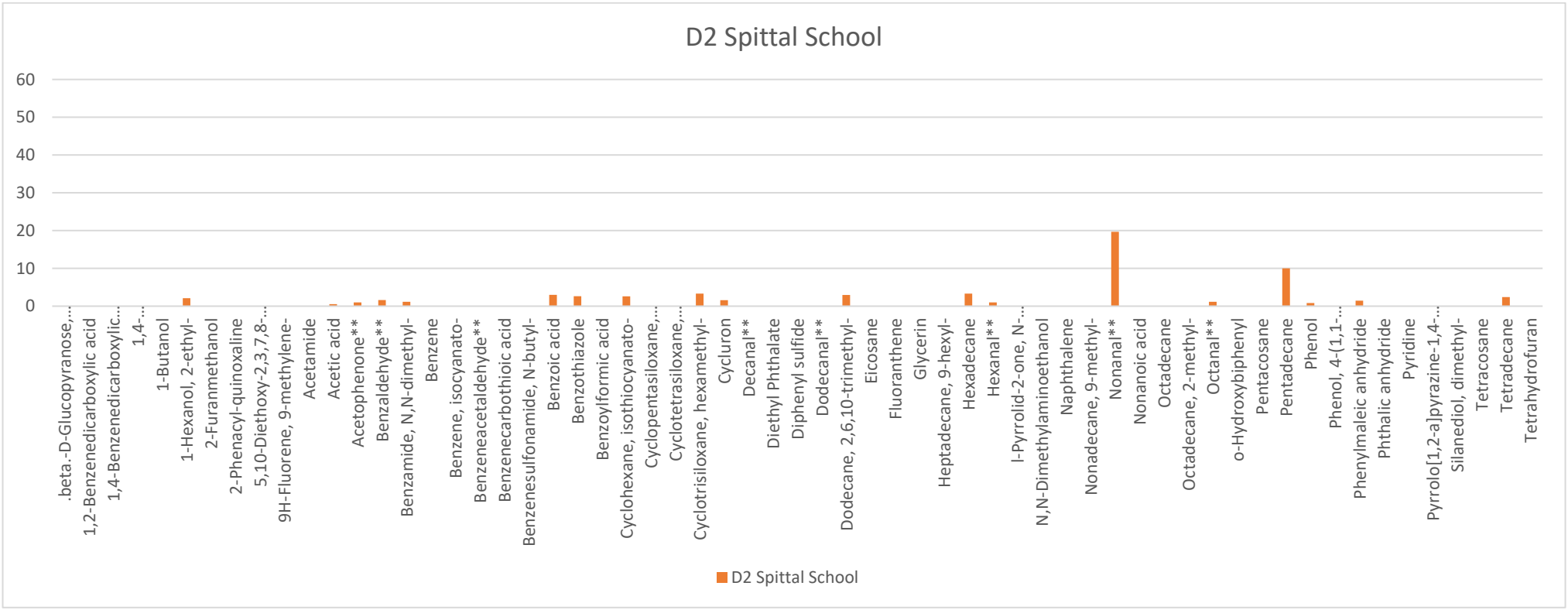


Chart 3-3 VOC's at D3

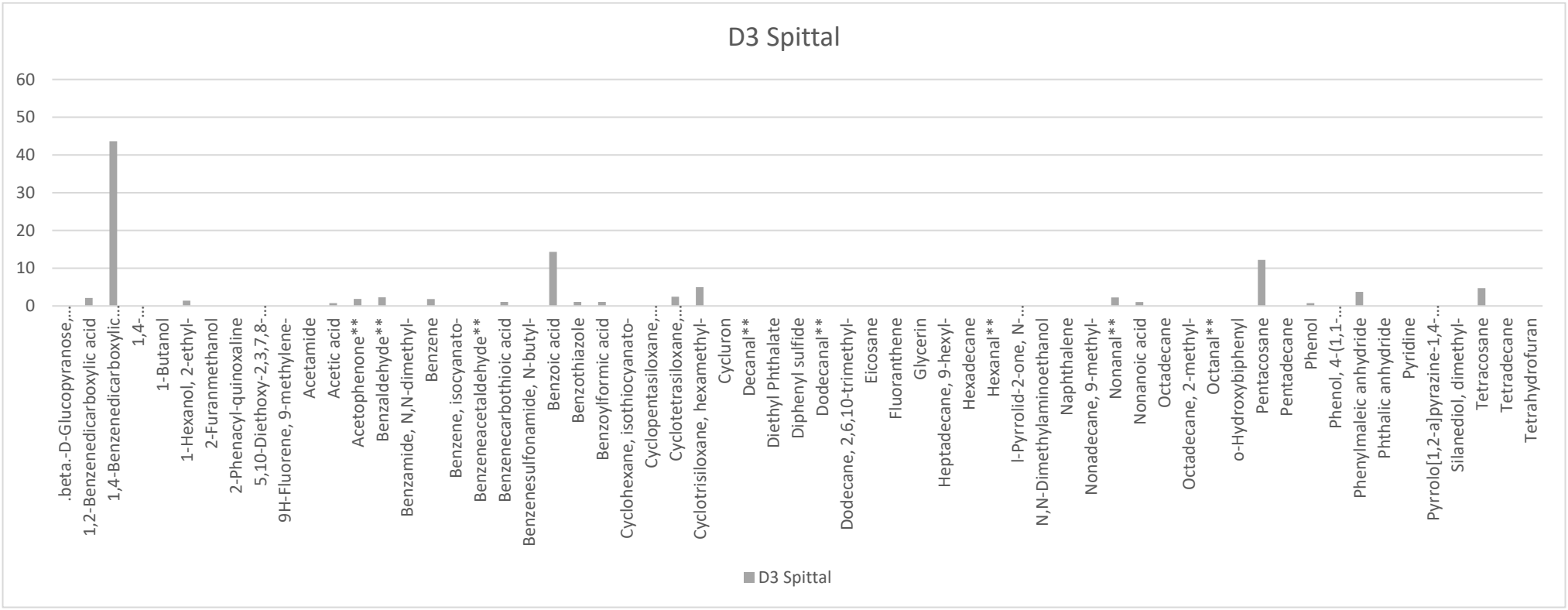


Chart 3-4 VOC's at D4

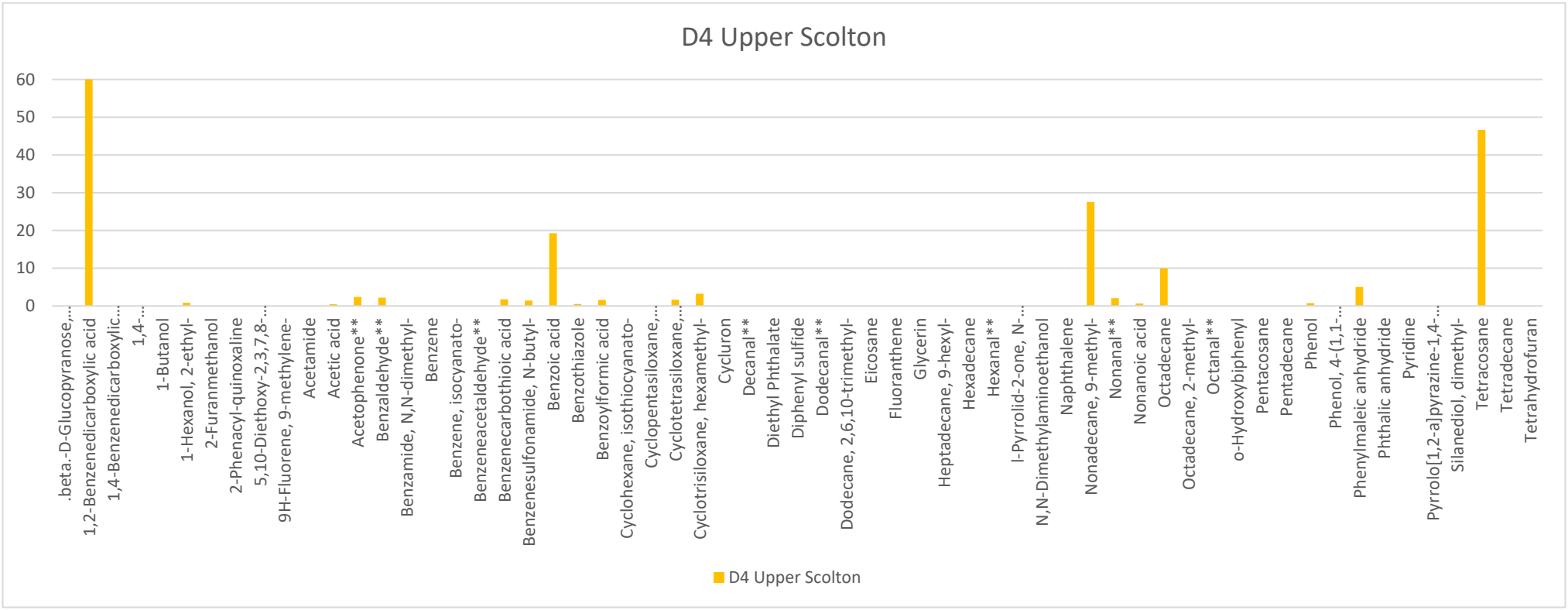


Chart 3-5 VOC's at D5

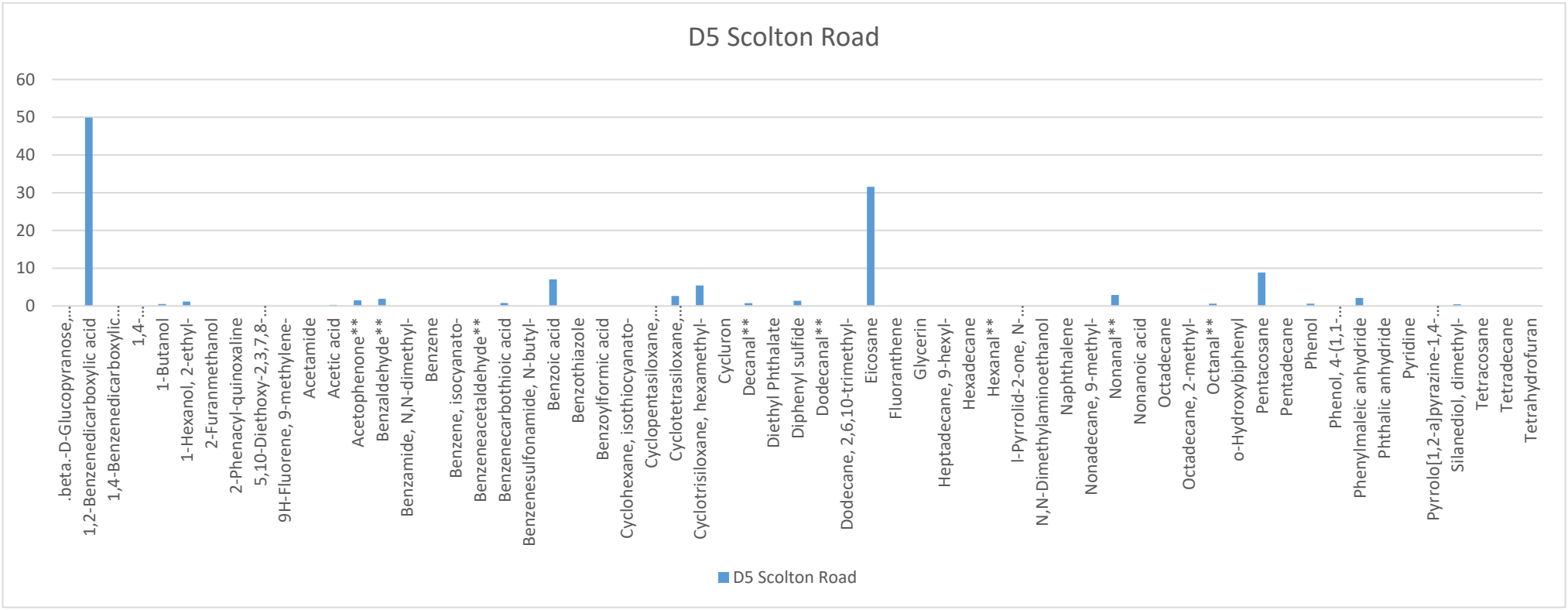


Chart 3-6 VOC's at D6

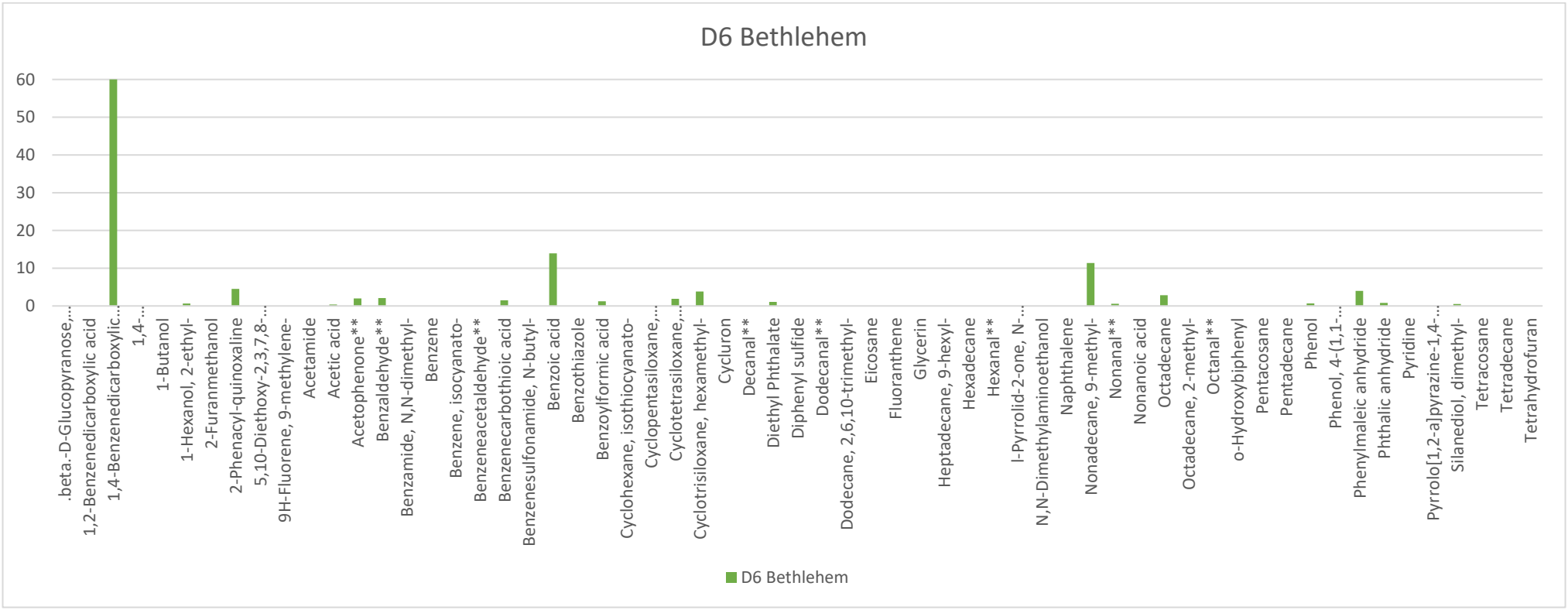


Chart 3-7 VOC's at D7

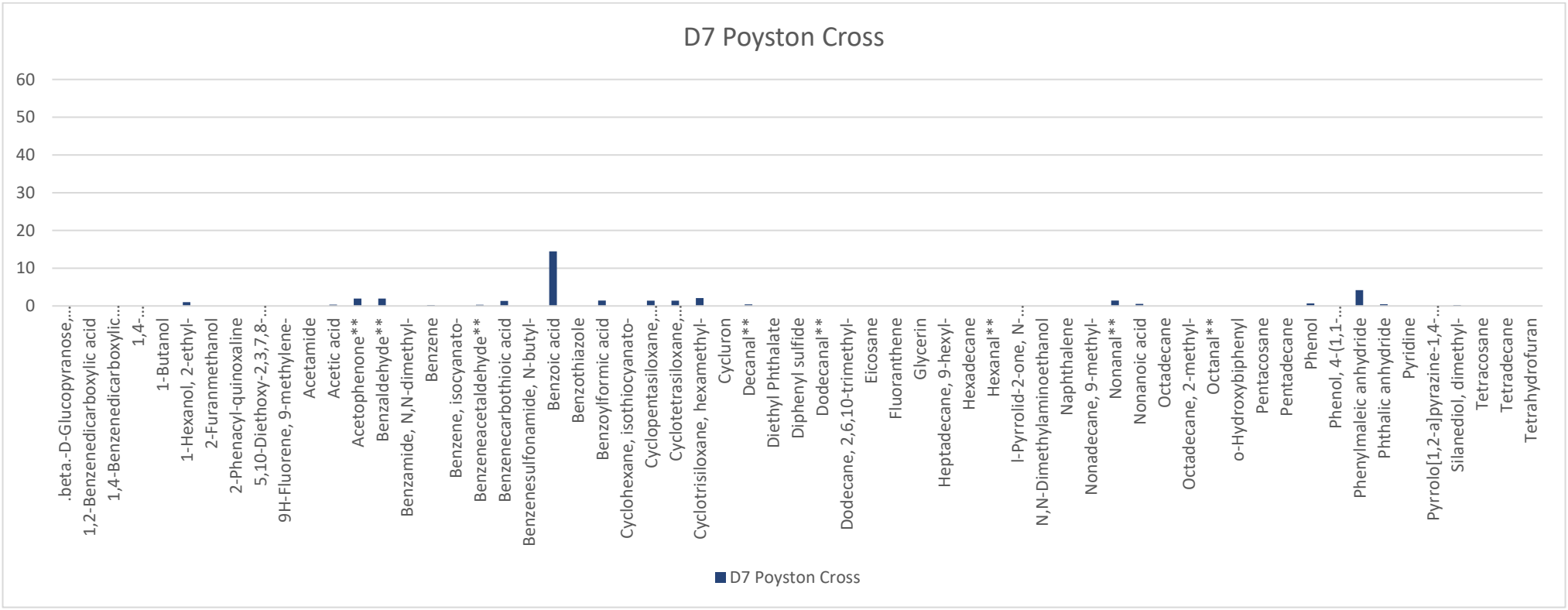


Chart 3-8 VOC's at D8

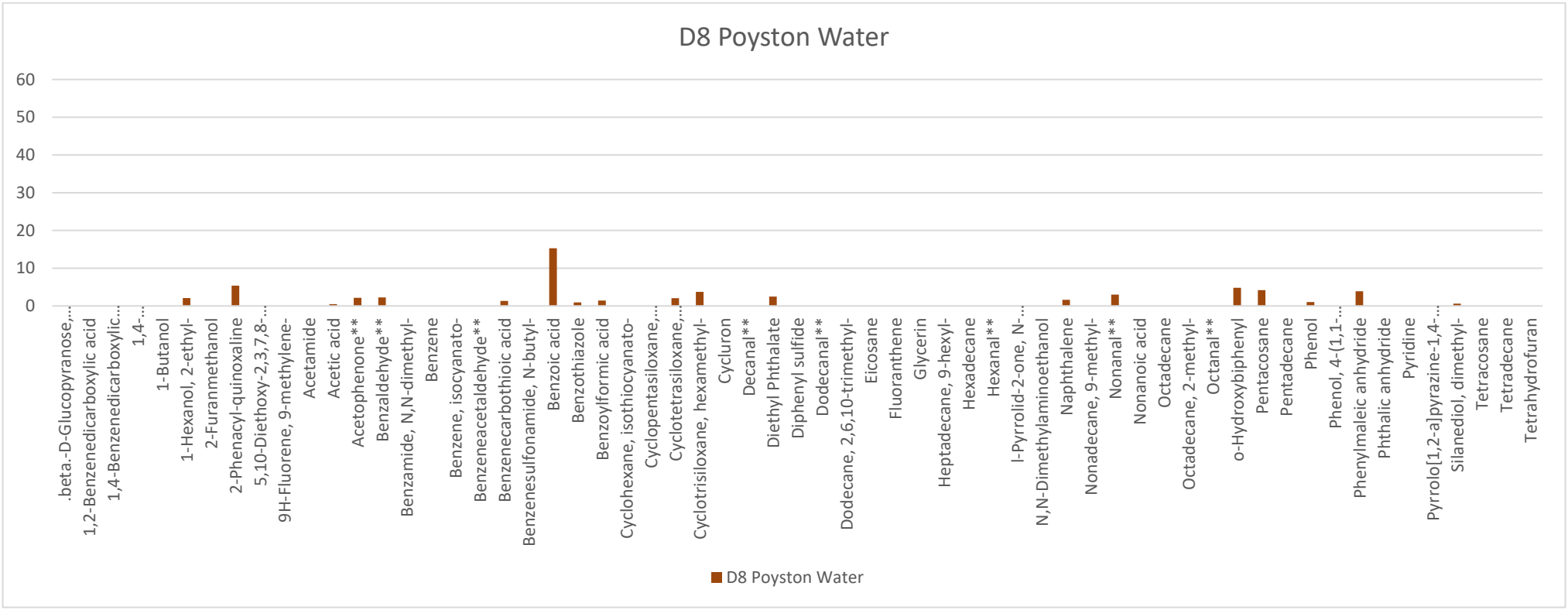


Chart 3-9 VOC's at D9

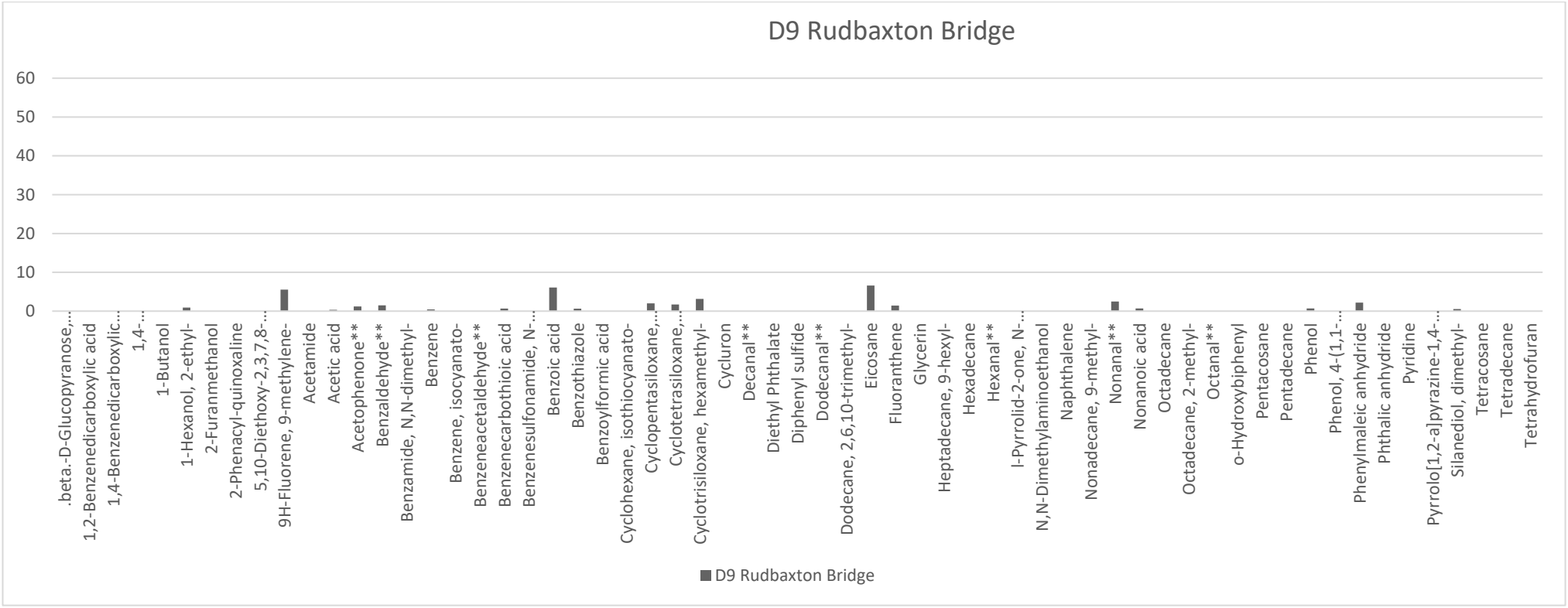


Chart 3-10 VOC's Detected at D10

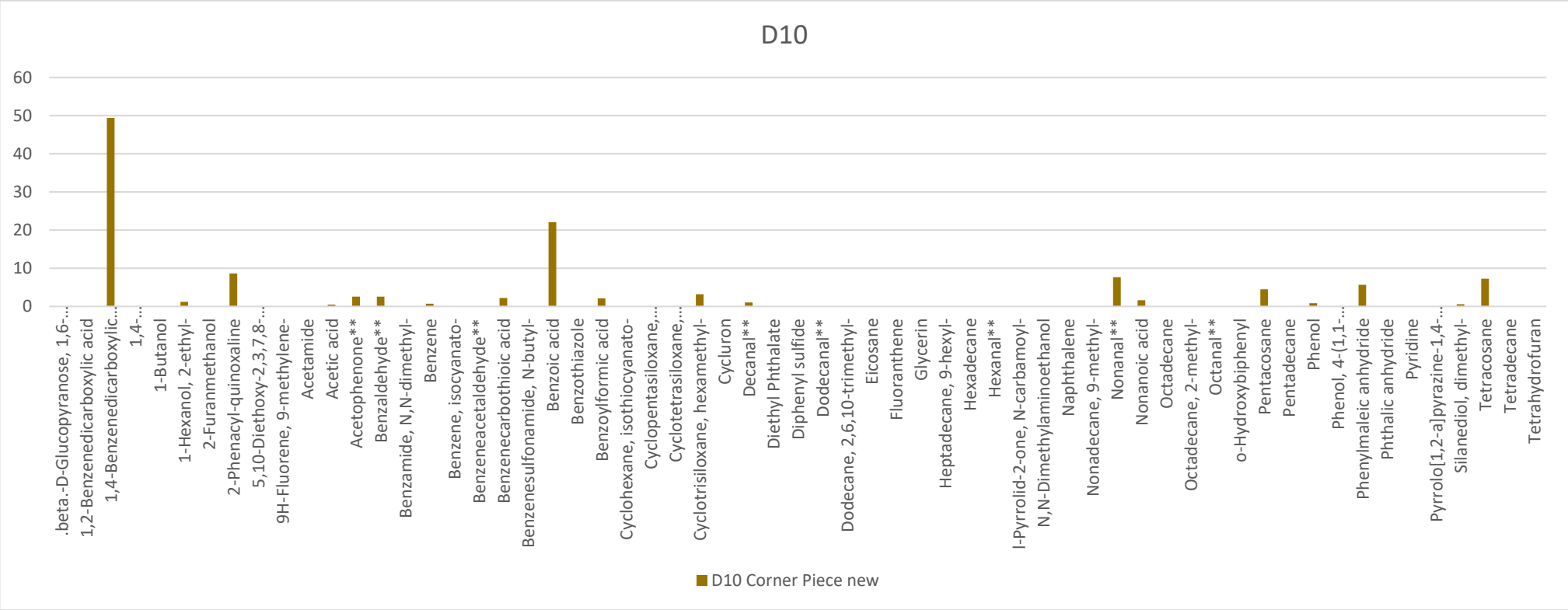
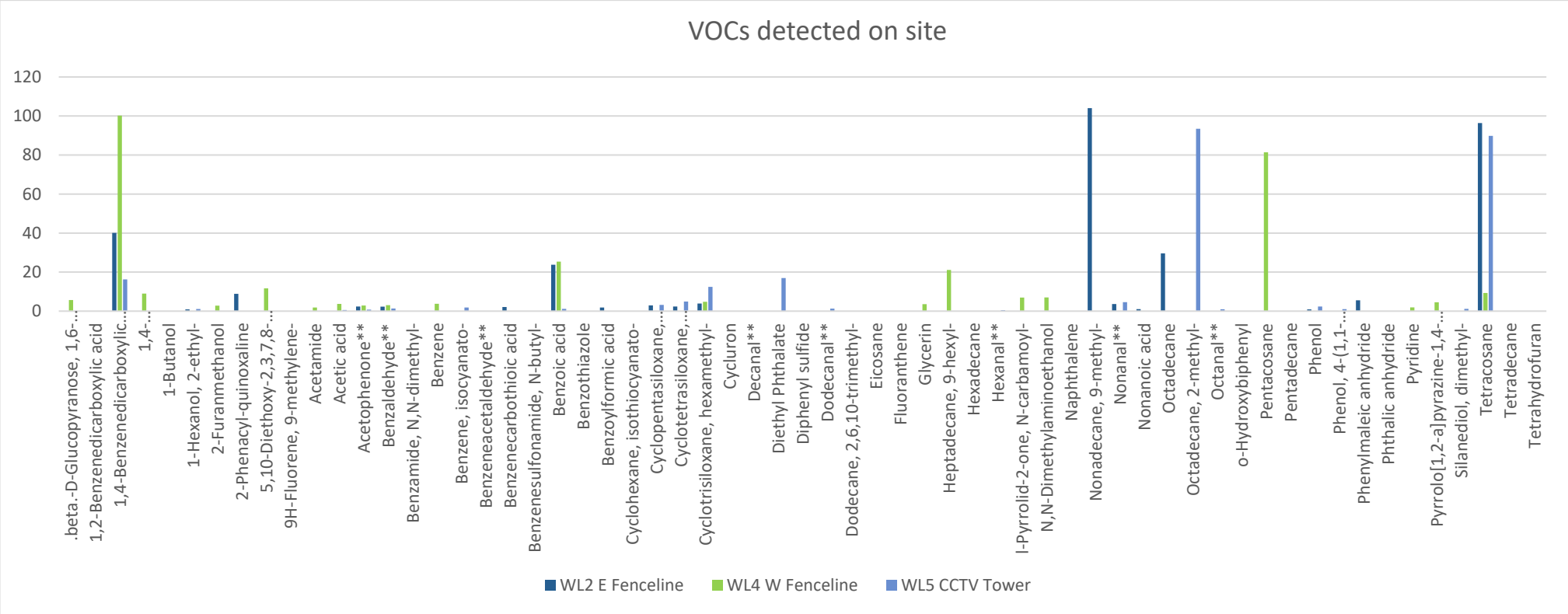


Chart 3-11 VOC's Detected on site



4 INSTANTANEOUS MONITORING OF HYDROGEN SULPHIDE

4.1 Monitoring using a Jerome Analyser

The Jerome® J605 Hydrogen Sulphide Analyzer analyser has been used since 14 March 2024. The hand-held instrument contains a gold film sensor that is sensitive to Hydrogen Sulphide. To take a sample, an internal pump pulls ambient air over the gold film sensor. The sensor absorbs the hydrogen sulphide present in the sample and undergoes an increase in electrical resistance proportional to the mass of Hydrogen Sulphide. This allows the instrument to calculate and display the measured concentration of hydrogen sulphide. Measurements below 3ppb are reported as zero and at 5ppb the instrument has an accuracy of ±1ppb and a precision of 10%. In practice, this means a displayed value of 0ppb is <3ppb and a reported value of 5ppb is equivalent to an actual concentration of about 4-6ppb. The current calibration certification for the Jerome instrument being used is provided in Appendix 3.

Using the Jerome, monitoring data has been gathered using several different approaches:

- 30 minute logging of airborne Hydrogen Sulphide at 5-minute intervals – in this mode the instrument takes a measurement automatically every 5 minutes.
- 24-hr (or more) of logging airborne Hydrogen Sulphide at 15-minute intervals
- Spot levels – where measurements have been made in real-time at different locations.

This data is presented in this report as parts per billion (ppb). The full dataset is included in Appendix 4.

For each approach the same protocol has been followed with the instrument undergoing a 45-minute 'regeneration' process at the start and end of each day, as dictated by the sensor saturation. At the start of each monitoring interval a 5-minute 'warm-up' routine with a Zero Air Filter has also been undertaken.

4.2 Monitoring in Community

Appendix 5 contains the results of 30-minute logging undertaken around the Withyhedge Landfill site. This includes the positions referenced D1-D12 and also other positions which are identified. Also included is commentary related to the observation of odour at the time of monitoring including wind speed, wind direction, odour type/source and perceived intensity.

In addition to the 30-minute measurements, spot measurements have also been taken and this data is presented in Appendix 6.

4.3 Monitoring at Withyhedge Landfill

Alongside the measurement of Hydrogen Sulphide in the community areas, the Jerome has also been used to take spot measurements at positions around the landfill site. This data is also presented in Appendix 5. This monitoring confirms the presence of elevated levels of Hydrogen Sulphide on site measured using a Jerome.

4.4 Review of Data

As the data from the Jerome monitor is gathered over short timescales, it is considered appropriate, at this stage, to evaluate the data against criteria intended to enable the assessment of such short-term exposure rather than the longer-term exposure criteria summarised in Table 3-4. Such short-term criteria are sometimes referred to as acute criteria. In the absence of specific UK criteria, an example of such criteria is presented in Table 4-1 which have been developed by the World Health Organisation (WHO).

Table 4-1 WHO Air Quality Guidelines

Short-term WHO air quality guideline	Hydrogen Sulphide guideline value/ppb	Note
30-minute (average)	5	Short-term odour value protective of odour annoyance. The guideline was developed by a panel of experts following a review of available information and consideration of the odour threshold for hydrogen sulphide which was reported to be in range 0.5 ppb – 130 ppb based on experimental studies at the time.
24-hour (average)	107	This value was derived from studies of eye irritation in humans.

The monitoring in the community indicates that there are several different types of odour present including odour suspected to be from the landfill and odours suspected to be related to a range of agricultural activities. Many readings of Hydrogen sulphide reported by the Jerome analyser are close to or below the detection limit during the latest monitoring period and there are few recorded values above the lower 5ppb guideline value. It is evident from the repeated use of the instrument at different times of day over several days that such concentrations are not persistent over such time-frames. At many monitoring positions on different occasions the Jerome was not able to detect Hydrogen Sulphide above the level of detection. It is also evident that during June 2024, lower levels of Hydrogen Sulphide were detected at the landfill site monitoring positions with the maximum concentration detected 46ppb and on some days the concentrations at P1-P9 were found to be lower than 5ppb. All data falls below the 24-hr guideline average of 107 ppb.

During this most recent monitoring, impersistent elevated levels of Hydrogen Sulphide were recorded during 30-minute monitoring at D11 on 19 June (up to 31.66ppb) and during a spot measurement at D1 on 15 June (49.35ppb). Based on observations made at the time, this data is considered to have been influenced by emissions from vehicle exhausts. At D12, a van parked close to the monitoring position with its engine idling before driving off. At D1, a lorry passed as the initial reading was being taken with the repeat reading a minute later reporting 3.09ppb.

Other spot measurements of Hydrogen Sulphide reported in Appendix 6 include 10.67ppb close (~3m) to a pile of manure near position D5 on 20 June, 9.57ppb near a farm at Sealyham (north-east of Wolf's Castle) on 15 June and lower detectable levels of Hydrogen Sulphide sometimes associated with a range of different suspected odours.

5 SUMMARY

The recorded concentrations of hydrogen sulphide measured at each diffusion tube placed within surrounding communities have averaged 0.2ppb or less since the start of monitoring in early February 2024. These time integrated average concentrations are lower than the lifetime exposure criteria of 1ppb.

With the benefit of the data gathered from the Jerome monitor, it is now evident that the instantaneous concentration of Hydrogen Sulphide in the community settings varies although the dataset is complex and many readings are close to the detection limit of the instrument.

Many readings of Hydrogen sulphide reported by the Jerome analyser are close to or below the detection limit during the latest monitoring period and there are few recorded values above the 5ppb guideline value. It is evident from the repeated use of the instrument at different times of day over several days that such concentrations are not persistent over such time-frames. At many monitoring positions on different occasions the Jerome was not able to detect Hydrogen Sulphide above the level of detection.

During this monitoring period, diffusion tubes have once again been used to assess for the presence of VOCs. Low concentration levels continue to be found and it appears that Hydrogen Sulphide is still a useful target compound for trying to detect the presence of odours. In this context, VOC monitoring is planned to be reduced.

References

Ref 1. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological profile for Hydrogen Sulphide, 2006.
Ref 2. U.S. Environmental Protection Agency Reference Concentration for Hydrogen Sulphide.
Ref 3. EH40/2005 Workplace exposure limits (Fourth Edition 2020)