Electronic Supplementary Material (ESI) for Environmental Science: Processes & Impacts

Quantitative Passive Soil Vapor Sampling for VOCs: Field Experiments

Todd McAlary[1,2*], *Hester Groenevelt*[1], *Paul Nicholson*[1], *Suresh Seethapathy*[2], *Paolo Sacco*[3], *Derrick Crump*[4], *Michael Tuday*[5], *Heidi Hayes*[7], *Brian Schumacher*[6], *Paul Johnson*[8], *Tadeusz Górecki*[2] *and Ignacio Rivera-Duarte*[9]

[1] Geosyntec Consultants, Inc. 130 Research Lane, #2, Guelph, Ontario, N1G 5G3

[2] University of Waterloo, Waterloo, Ontario Canada

[3]Fondazione Salvatore Maugeri, Padova, Italy

[4]Cranfield University, Cranfield, UK

[5]Columbia Analytical Services, Simi Valley, CA

[6]USEPA, Las Vegas, NV

[7]Eurofins/Air Toxics, Inc. (formerly Air Toxics Ltd.), Folsom, CA

[8]Arizona State University, Tempe, AZ

[9] SPAWAR Systems Center Pacific, San Diego, CA

ELECTRONIC SUPPLEMENTAL INFORMATION

Laboratory Methods of Analysis

All samples were analyzed by Air Toxics of Folsom, CA, with the following exceptions:

- Radiello samplers used at Hill AFB and NAS Jacksonville were analysed by Fondazione Salvatori Maugeri of Padova, Italy,
- the SKC samplers used at Hill AFB and NAS Jacksonville was analyzed by Columbia Analytical Services, Simi Valley, CA,

[*] Corresponding Author - phone: (519) 822-2230 ext 239; fax (519) 822-3151; e-mail: tmcalary@geosyntec.com

- the WMS samplers at Hill AFB was analyzed by the University of Waterloo, Ontario, Canada,
- the Summa® canister samples for Hill AFB and NAS Jacksonville were analyzed by Columbia Analytical Services.

All Summa® canister samples were analyzed by EPA Method TO-15. The charcoal-based passive samplers were analyzed by adding 1 to 2 mL of low-benzene content carbon disulfide in a closed inert vial and allowing 30 minutes on a shaker. An aliquot of 1 or 2 μL was injected via auto-injector into a GC/MS and the mass of analytes were determined using an internal standard calibration technique (Radiello) or external calibration (WMS). The thermally-desorbable sorbents were transferred (if needed) into an automatic thermal desorption (ATD) tube, and the tubes were placed in an auto-injection carousel for analysis by GC/MS using EPA Method TO-17. The samples were analyzed for site-specific compounds of interest.

One trip blank sample was collected and analyzed for each passive sampler type for each field site. TCE was detected at 23.4 ng in the SKC blank for the NAS JAX event, so the investigative samples were corrected for the blank. All other trip blanks had no detectable concentrations of target analytes.

Table S1: Passive soil vapor concentrations, average active sampling concentrations and relative concentrations (C/C_o) for 1,1-DCE at the Layton House, Utah. Bold and italics indicate average active sampling concentrations where one value was not included because of suspected low bias due to incomplete purging.

Compound	Sample Time (t) (days)	Sampler	Soil Gas Probe #	Passive Concentration (ug/m^3)	Average Active Concentration (ug/m^3)	C/C_o (Passive / Active)	Uptake Rate (UR) (mL/min)	UR x t (L)
1,1-DCE	1.0	ATD CarbopackB	SGP-1	178	326	0.55	0.57	0.8
		Radiello Charcoal	SGP-3	15	482	0.03	79	118.8
		SKC Charcoal	SGP-6	--	--	--	1.3	1.9
		ATD Tenax TA	SGP-2	106	393	0.27	0.6	0.8
		WMS Anasorb	SGP-4	348	469	0.74	0.82	1.2
	2.0	ATD CarbopackB	SGP-3	277	365	0.76	0.57	1.7
		Radiello Charcoal	SGP-5	1.51U	89	< 0.02	79	235.2
		SKC Charcoal	SGP-2	209	406	0.51	1.3	3.8
		ATD Tenax TA	SGP-4	103	221	0.46	0.6	1.7
		WMS Anasorb	SGP-6	250	264	0.94	0.82	2.4
	2.2	ATD CarbopackB	SGP-2	434	425	1.02	0.57	1.8
		Radiello Charcoal	SGP-4	17	165	0.10	79	249.6
		SKC Charcoal	SGP-1	99	***290***	0.34	1.3	4.1
		ATD Tenax TA	SGP-3	51	365	0.14	0.6	1.8
		WMS Anasorb	SGP-5	35	87	0.41	0.82	2.6
	7.9	ATD CarbopackB	SGP-6	70	212	0.33	0.57	6.5
		Radiello Charcoal	SGP-2	13	312	0.04	79	910.1
		SKC Charcoal	SGP-5	30	52	0.57	1.3	14.8
		ATD Tenax TA	SGP-1	79	207	0.38	0.6	6.5
		WMS Anasorb	SGP-3	250	272	0.92	0.82	9.3
	8.1	ATD CarbopackB	SGP-5	15	***49***	0.30	0.57	6.6
		Radiello Charcoal	SGP-1	2	155	0.01	79	928.8
		SKC Charcoal	SGP-4	393	144	2.74	1.3	15.1
		ATD Tenax TA	SGP-6	4	166	0.02	0.6	6.6
		WMS Anasorb	SGP-2	327	370	0.88	0.82	9.5
	9.8	ATD CarbopackB	SGP-4	75	177	0.42	0.57	8.1
		Radiello Charcoal	SGP-6	49	154	0.32	79	1,132.8
		SKC Charcoal	SGP-3	133	243	0.55	1.3	18.4
		ATD Tenax TA	SGP-5	7	***77***	0.09	0.6	8.1
		WMS Anasorb	SGP-1	130	186	0.70	0.82	11.6
	11.7	ATD CarbopackB	SGP-1	22	346	0.06	0.57	9.6
		Radiello Charcoal	SGP-3	14	109	0.13	79	1,344.0
		SKC Charcoal	SGP-6	too wet	351	---	1.3	21.8
		ATD Tenax TA	SGP-2	3	330	0.01	0.6	9.6
		WMS Anasorb	SGP-4	363	154	2.35	0.82	13.8

Table S2: Passive soil vapor concentrations, average active sampling concentrations and relative concentrations (C/C_o) for TCE at the Layton House, Utah. Bold and italics indicate average active sample concentrations where one value was not included because of suspected low bias due to incomplete purging.

Compound	Sample Time (t) (days)	Sampler	Soil Gas Probe #	Passive Concentration (ug/m^3)	Average Active Concentration (ug/m^3)	C/Co (Passive/ Active)	Uptake Rate (UR) (mL/min)	UR x t (L)
TCE	1.0	ATD Carbopack B	SGP-1	342	374	0.91	0.5	0.7
		Radiello Charcoal	SGP-3	65	452	0.14	69	102.5
		SKC Charcoal	SGP-6	77	280	0.27	0.58	0.9
		ATD Tenax TA	SGP-2	151	492	0.31	0.5	0.7
		WMS Anasorb	SGP-4	210	380	0.55	3.28	4.9
	2.0	ATD Carbopack B	SGP-3	611	488	1.25	0.5	1.5
		Radiello Charcoal	SGP-5	7	111	0.06	69	202.9
		SKC Charcoal	SGP-2	541	555	0.98	0.58	1.7
		ATD Tenax TA	SGP-4	300	271	1.11	0.5	1.5
		WMS Anasorb	SGP-6	182	282	0.64	3.28	9.6
	2.2	ATD Carbopack B	SGP-2	611	555	1.10	0.5	1.6
		Radiello Charcoal	SGP-4	48	286	0.17	69	215.3
		SKC Charcoal	SGP-1	345	***492***	0.70	0.58	1.8
		ATD Tenax TA	SGP-3	319	461	0.69	0.5	1.6
		WMS Anasorb	SGP-5	53	118	0.45	3.28	10.2
	7.9	ATD Carbopack B	SGP-6	77	261	0.30	0.5	5.7
		Radiello Charcoal	SGP-2	43	691	0.06	69	784.9
		SKC Charcoal	SGP-5	113	96	1.18	0.58	6.6
		ATD Tenax TA	SGP-1	286	424	0.68	0.5	5.7
		WMS Anasorb	SGP-3	301	631	0.48	3.28	37.3
	8.1	ATD Carbopack B	SGP-5	103	***105***	0.99	0.5	5.8
		Radiello Charcoal	SGP-1	22	348	0.06	69	801.1
		SKC Charcoal	SGP-4	728	292	2.49	0.58	6.7
		ATD Tenax TA	SGP-6	13	207	0.06	0.5	5.8
		WMS Anasorb	SGP-2	347	710	0.49	3.28	38.1
	9.8	ATD Carbopack B	SGP-4	287	260	1.10	0.5	7.1
		Radiello Charcoal	SGP-6	69	201	0.34	69	977.0
		SKC Charcoal	SGP-3	511	424	1.21	0.58	8.2
		ATD Tenax TA	SGP-5	63	***98***	0.64	0.5	7.1
		WMS Anasorb	SGP-1	219	345	0.64	3.28	46.4
	11.7	ATD Carbopack B	SGP-1	279	***295***	0.95	0.5	8.4
		Radiello Charcoal	SGP-3	21	402	0.05	69	1,159.2
		SKC Charcoal	SGP-6	too wet	144	---	0.58	9.7
		ATD Tenax TA	SGP-2	11	476	0.02	0.5	8.4
		WMS Anasorb	SGP-4	238	280	0.85	3.28	55.1

Table S3: Passive and Active Soil Vapor Concentrations for four VOCs in soil gas (SG) probes and sub-slab probes (SSPs) at NAS Jacksonville.

Sampler Type (Subtype/Sorbent)	Sample ID	Void Space Volume (L)	Exposure Time (min)	Concentration (µg/m3)							
				cis-1,2-DCE		PCE		trans-1,2-DCE		TCE	
				Passive Sampler	Summa Canister	Passive Sampler	Summa Canister	Passive Sampler	Summa Canister	Passive Sampler	Summa Canister
3M OVM (Regular/ charcoal)	SG-FP-20-1	1	20	1,136	1,600	424	560	384	480	145	180
	SG-FP-20-3	3	20	1,065	1,200	477	540	384	360	151	130
	SG-FP-40-2-A	2	40	1,705	2,300	601	760	490	560	185	220
	SG-FP-40-2-B	2	40	2,273	3,900	724	990	639	800	217	290
	SG-FP-40-2-C	2	40	1,705	2,600	689	1,000	518	600	193	250
	SG-FP-60-1	1	60	994	1,600	277	480	331	520	102	160
	SG-FP-60-3	3	60	1,278	1,800	518	630	469	520	166	170
ATD Tube (Regular/ Carbopack B)	SG-FP-20-1	1	20	2,157	1,700	1,024	560	637	520	310	180
	SG-FP-20-3	3	20	1,961	1,300	902	530	627	380	270 U	140
	SG-FP-40-2-A	2	40	3,775	2,100	1,098	590	833	490	280	180
	SG-FP-40-2-B	2	40	3,382	2,700	1,524	1,000	833	620	340	260
	SG-FP-40-2-C	2	40	3,284	2,500	1,585	940	784	540	330	230
	SG-FP-60-1	1	60	2,484	1,400	976	560	654	390	250	170
	SG-FP-60-3	3	60	1,699	1,200	894	520	523	340	203	130
WMS (0.8 mL Amber Vial / Anasorb 747)	SG-FP-20-1	1	20	1,806	1,700	670	690	9,823 U	500	162 U	190
	SG-FP-20-3	3	20	1,521	1,300	580	520	9,823 U	370	380	140
	SG-FP-40-2-A	2	40	3,897	2,900	1,004	950	4,912 U	650	340	250
	SG-FP-40-2-B	2	40	2,757	2,600	1,071	1,300	4,912 U	720	340	290
	SG-FP-40-2-C	2	40	2,757	2,400	1,049	930	4,912 U	540	312	230
	SG-FP-60-1	1	60	1,648	1,500	565	550	3,274 U	410	227	170
	SG-FP-60-3	3	60	1,553	1,300	625	520	3,274 U	380	265	140
Radiello (Yellow body/ Charcoal)	SG-FP-20-1	1	20	1,730	2,000	295 U	480	476 U	580	369 U	170
	SG-FP-20-3	3	20	1,222	2,200	295 U	790	476 U	650	369 U	220
	SG-FP-40-2-A	2	40	2,794	2,400	148 U	720	238 U	580	185 U	210
	SG-FP-40-2-B	2	40	2,143	2,300	226	690	294	540	185 U	200
	SG-FP-40-2-C	2	40	2,452	2,400	315	940	310	530	185 U	220
	SG-FP-60-1	1	60	1,831	1,800	98 U	650	275	520	123 U	190
	SG-FP-60-3	3	60	1,582	1,600	348	610	307	460	123 U	160
SKC* (12-hole cap, Carbograph 5)	SG-FP-20-1	1	20	2,704	1,800	1,040	730	770	520	*	200
	SG-FP-20-3	3	20	2,129	1,200	648	520	634	340	407	130
	SG-FP-40-2-A	2	40	3,758	2,100	875	920	806	510	546	230
	SG-FP-40-2-B	2	40	3,356	2,500	1,023	1,000	811	580	64	250
	SG-FP-40-2-C	2	40	3,236	2,400	920	990	747	550	139	230
	SG-FP-60-1	1	60	2,693	1,800	603	700	675	500	410	190
	SG-FP-60-3	3	60	2,683	1,300	558	550	734	390	572	140
ATD Tube (Pin-hole/ Carbopack B)	SSP-4	--	60	5,998	3,800	13,140	7,400	3,999	2,300	1,549	960
	SSP-5	--	60	7,331	4,400	28,332	17,000	8,331	4,900	3,030	1,900
	SSP-6	--	60	21,328	14,000	49,273	18,000	29,326	19,000	7,071	3,400
WMS (0.8 mL Amber Vial / Anasorb 747)	SSP-4	--	60	4,753	3,800	8,185	7,400	2,679 U	2,300	1,134	960
	SSP-5	--	60	4,753	4,400	17,857	17,000	5,566	4,900	2,079	1,900
	SSP-6	--	60	18,695	14,000	26,786	18,000	29,470	19,000	4,913	3,400
Radiello (Yellow body/ Charcoal)	SSP-4	--	60	2,233	3,800	1,850	7,400	1,344	2,300	326	960
	SSP-5	--	60	2,820	4,400	4,770	17,000	2,952	4,900	1,224	1,900
	SSP-6	--	60	10,444	14,000	6,535	18,000	13,233	19,000	2,620	3,400

Notes

*The SKC trip blank contained a significant level of TCE (23.4 ng); this mass was subtracted from the sample masses. Sample SG-FP-20-1-SKCPH had less than 23.4 ng TCE on it, so this result is excluded from the table

49 Table S4: ANOVA Analysis of NAS JAX Fractional Factorial Soil Gas Sample Results

ANOVA for cis-1,2-DCE

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
sampler	4	2.73751	0.68438	18.6175	4.41E-05	***
as.factor(time)	1	0.05783	0.05783	1.5732	0.2336	
as.factor(volume)	1	0.03638	0.03638	0.9897	0.3395	
as.factor(time):as.factor(volume)	1	0.00074	0.00074	0.02	0.8898	
Residuals	12	0.44112	0.03676			

Regression Output for cis-1,2-DCE

Coefficients	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.62993	0.12126	5.195	0.000224	***
samplerATD Carbopack	0.75938	0.13557	5.601	0.000116	***
samplerRadiello	0.12419	0.13557	0.916	0.377693	
samplerSKC-PH	0.9767	0.13557	7.204	1.08E-05	***
samplerWMS	0.39885	0.13557	2.942	0.012327	*
as.factor(time)60	0.11968	0.12126	0.987	0.34314	
as.factor(volume)3	0.09744	0.12126	0.804	0.437299	
as.factor(time)60:as.factor(volume)3	-0.02427	0.17149	-0.142	0.889811	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.1917 on 12 degrees of freedom
Multiple R-squared: 0.8652, Adjusted R-squared: 0.7866
F-statistic: 11.01 on 7 and 12 DF, p-value: 0.0002198

ANOVA for PCE - Does not include Radiello

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
sampler	3	2.04674	0.68225	33.6161	3.22E-05	***
as.factor(time)	1	0.05791	0.05791	2.8534	0.1254	
as.factor(volume)	1	0.01674	0.01674	0.8249	0.3874	
as.factor(time):as.factor(volume)	1	0.02126	0.02126	1.0475	0.3328	
Residuals	9	0.18266	0.0203			

Regression Output for PCE - Does not include Radiello

Coefficients	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.824235	0.094229	8.747	1.08E-05	***
samplerATD Carbopack	0.988524	0.100735	9.813	4.19E-06	***
samplerSKC-PH	0.376342	0.100735	3.736	0.00465	**
samplerWMS	0.319189	0.100735	3.169	0.01139	*
as.factor(time)60	-0.19322	0.100735	-1.918	0.08731	.
as.factor(volume)3	-0.00820	0.100735	-0.081	0.93684	
as.factor(time)60:as.factor(volume)3	0.145809	0.142461	1.023	0.33279	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.1425 on 9 degrees of freedom
Multiple R-squared: 0.9214, Adjusted R-squared: 0.8691
F-statistic: 17.6 on 6 and 9 DF, p-value: 0.000167

ANOVA for trans-1,2-DCE - Does not include Radiello and WMS

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
sampler	2	1.46132	0.73066	24.6009	0.001284	**
as.factor(time)	1	0.00087	0.00087	0.0294	0.869403	
as.factor(volume)	1	0.25109	0.25109	8.4539	0.027066	*
as.factor(time):as.factor(volume)	1	0.01452	0.01452	0.4889	0.510601	
Residuals	6	0.1782	0.0297			

Regression Output for trans-1,2-DCE - Does not include Radiello and WMS

Coefficients	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.6799	0.1219	5.579	0.001408	**
samplerATD Carbopack	0.6718	0.1219	5.513	0.001497	**
samplerSKC-PH	0.7936	0.1219	6.512	0.000625	***
as.factor(time)60	0.0525	0.1407	0.373	0.721908	
as.factor(volume)3	0.3589	0.1407	2.55	0.043468	*
as.factor(time)60:as.factor(volume)3	-0.1391	0.199	-0.699	0.510601	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1723 on 6 degrees of freedom

Multiple R-squared: 0.9065, Adjusted R-squared: 0.8286

F-statistic: 11.63 on 5 and 6 DF, p-value: 0.00481

ANOVA for TCE - Does not include Radiello, one sample from ATD and one sample from SKC

Source	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
sampler	3	8.6945	2.89816	13.2417	0.002848	**
as.factor(time)	1	0.1951	0.19512	0.8915	0.376508	
as.factor(volume)	1	1.4277	1.42765	6.523	0.037881	*
as.factor(time):as.factor(volume)	1	0.028	0.02795	0.1277	0.731341	
Residuals	7	1.5321	0.21887			

Regression Output for PCE -Does not include Radiello, one sample from ATD and one sample from SKC

Coefficients	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.7448	0.3349	2.224	0.061521	.
samplerATD Carbopack	0.8213	0.3661	2.243	0.059788	.
samplerSKC-PH	2.1801	0.3661	5.954	0.000568	***
samplerWMS	0.9621	0.3308	2.908	0.022716	*
as.factor(time)60	-0.3354	0.3661	-0.916	0.390097	
as.factor(volume)3	0.5423	0.4052	1.338	0.22258	
as.factor(time)60:as.factor(volume)3	0.1869	0.5231	0.357	0.731341	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4678 on 7 degrees of freedom

Multiple R-squared: 0.871, Adjusted R-squared: 0.7604

F-statistic: 7.878 on 6 and 7 DF, p-value: 0.007726

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