Assessing environmental impact in an industrial site using an unmanned aerial vehicle with multi-spectral image camera

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Supplementary Information

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Table S1. Quality Control of XRF using Certified Reference Materials.

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Figure S1. Sampling locations: Site A Main Site Teesside Refinery and B Greatham Storage Depot, (a) photograph of the main site (Site A) pre-development, in 1969, (b) photograph of Greatham Storage Deport (Site B), 1974, (c) aerial photograph of Main Site (Site A), sampling area highlighted, (d) aerial photograph of Storage Depot (Site B), sampling area highlighted, (e) ground-based photograph of sampling locations at Main Site (Site A), and (f) ground-based photograph of sampling locations at the Storage Depot (Site B).

Figure S2. Vegetation index maps for an area of Site A (Main Site) (a) NDVI (b) GNDVI (c) SAVI and (d) CI green VI.

Figure S3. Vegetation index maps for an area of Site B (Storage Depot) (a) NDVI (b) GNDVI (c) SAVI and (d) CI green VI.

Figure S4. Relationship between VI and barium in Site A and Site B (a) NDVI and barium (b) GNDVI and barium (c) SAVI and barium and (d) CI green VI and barium.

Figure S5. Relationship between VI and C12-AS in Site A and Site B (a) NDVI and C12-AS (b) GNDVI and C12-AS (c) SAVI and C12-AS and (d) CI green VI and C12-AS.

Figure S6. Relationship between VI and tetradecylsulfate in Site A and Site B (a) NDVI and tetradecylsulfate in (b) GNDVI and tetradecylsulfate in (c) SAVI and tetradecylsulfate in and (d) CI green VI and tetradecylsulfate

Experimental

Metabolomic Analysis by Hydrophilic Liquid Interaction Chromatography Hi-Resolution Mass Spectrometry (Data dependent analysis)

Hydrophilic liquid interaction chromatography (HILIC) metabolite profiling was performed on a Vanquish Liquid Chromatography chromatographic separation system connected to an ID-X High Resolution Mass Spectrometer (Thermo Scientific, Hemel Hempstead, UK). The HILIC positive (ESI+) and negative (ESI-) MS data sets were acquired using the AcquireX acquisition workflow (data dependent analysis). The MS parameters were set as follows: MS^1 mass resolution 30 K, for MS^2 30 K stepped energy (HCD) 20, 35, 50 scan range 100–1000, RF lens (%) 35, automatic gain control (AGC) gain, intensity was set to 25% and minimum intensity threshold was set to 20,000 with an maximum injection time of 50 ms. An extraction blank was used to create the background MS/MS exclusion list and a pooled quality control (QC) was used to create the MS/MS inclusion list. Hydrophilic Liquid Interaction Chromatography (HILIC) separation was performed on a Waters Acquity UPLC BEH amide column (2.1 × 150 mm with particle size of 1.7 µm) operating at 45 °C with a flow rate of 200 µL/min. The liquid chromatography (LC) gradient consisted of a binary buffer system, buffer A (LC/MS grade water) and buffer B (LC/MS grade ACN), both containing 10 mM ammonium formate. Independent buffers systems were used for positive and negative ionization mode acquisition respectively; for positive ionization mode buffers pH was adjusted using 0.1% formic acid, whereas for negative ionization mode buffers pH was adjusted using 0.1% ammonia solution. The LC gradient was identical for both polarities, namely 95% B at T_0, hold for 1.5 min, followed by a linear decrease to 50% B in 11 min, a hold for 4 min, return to the starting conditions, and hold for further 4.5 min (column stabilization). The voltage applied for positive (ESI+) and negative (ESI-) ionization modes was 3.5 kV and 2.5 kV, respectively. Injection volumes used were 3 µL for positive ionization mode (ESI+) and 5 µL for negative ionization mode (ESI−).

Table S1. Quality Control of XRF using Certified Reference Materials

Element	Calibration range (µg/g)[&]	Number of data points	Y= MX + C[#]	R^2	Intra-precision (lowest concentration) %RSD (n = 6)	Intra-precision (highest concentration) %RSD (n = 6)	LLOD (µg/g)*	LOQ (µg/g)*
V	59.5 - 334	5	0.4529x +16.512	0.9867	2.4	2.1	3.7	11.3
Ni	22.1 - 129	6	1.3465x – 28.702	0.9843	1.2	0.8	1.2	3.8
Zn	29.7 - 9191	6	0.7695x + 158.37	0.9857	0.9	0.8	24.3	73.6
As	5.3 - 658	6	0.9643x + 5.4947	0.9975	2.1	0.3	2.7	8.2
Rb	83.6 - 227	5	1.0391x + 0.6971	0.9983	0.2	0.4	0.9	2.7
Sr	35.8 - 220	5	1.079x + 2.8082	0.9889	0.3	0.5	0.5	1.4
Y	15.9 - 111	5	0.9213x + 1.4721	0.9984	0.5	0.5	0.5	1.5
Zr	171 - 264	5	0.9887x + 9.0014	0.9858	0.5	0.1	6.6	20.0
Ba	371 - 8803	6	0.507 – 231.94	0.9778	1.6	1.1	4.8	14.5
Pb	27.0 - 2706	5	0.9948x + 15.897	0.9994	0.7	0.4	10.8	32.8

[&] minimum and maximum concentration of CRMs

used to correct sample data

* Determined using CRM calibration data. The lower limit of detection (LLOD) and limit of quantification (LOQ) were determined using replicate preparation of the calibration curve using the equations: LOD = 3.3σ/s and LOQ = 10σ/s, where σ is the standard deviation of the intercept and s is the slope.

Table S2. Concentration (µg/g) of elements (a) Main Site Teesside Terminal (Site A)[#], and (b) Greatham Oil Storage Depot (Site B)[#].

(a)

SAMPLE[@]		V	Ni	Zn	As	Rb	Sr	Y	Zr	Ba	Pb
3.1	mean	341.3	54.4	93.7	12.2	63.2	169.3	21.7	218.9	10729	90.8
	replicates	*363.0, 319.7*	*55.3, 53.5*	*99.6, 87.8*	*13.0, 11.4*	*64.8, 61.6*	*177.3, 161.3*	*22.4, 21.0*	*212.6, 225.2*	*10992, 10465*	*99.4, 82.2*
3.2	mean	336.0	50.9	ND	13.1	63.1	274.8	20.3	213.1	20763	90.1
	replicates	*364.7, 307.3*	*51.8, 50.0*	*ND, ND*	*13.8, 12.3*	*64.0, 62.2*	*278.5, 271.2*	*20.3, 20.2*	*206.5, 219.6*	*20477, 21049*	*95.0, 85.2*
3.3	mean	335.7	52.6	52.7	12.6	62.4	281.6	22.7	223.1	19688	86.7
	replicates	*367.6, 303.8*	*53.7, 51.5*	*62.5, 42.9*	*14.0, 11.1*	*63.5, 61.3*	*291.6, 271.6*	*23.5, 22.0*	*230.1, 216.0*	*19763, 19613*	*96.1, 77.3*
3.4	mean	348.9	55.0	205.9	12.8	64.6	273.4	23.3	239.1	18955	99.2
	replicates	*381.1, 316.8*	*56.0, 54.1*	*216.5, 195.2*	*13.8, 11.7*	*65.4, 63.8*	*267.1, 279.1*	*23.1, 23.4*	*238.1, 240.1*	*17840, 20069*	*104.2, 94.1*
3.5	mean	322.0	54.3	149.2	11.2	64.9	243.0	22.4	230.8	17216	70.9
	replicates	*379.1, 264.9*	*55.3, 53.3*	*162.6, 135.7*	*12.4, 9.9*	*66.5, 63.2*	*245.9, 240.1*	*21.8, 22.9*	*238.8, 222.8*	*16801, 17631*	*78.8, 62.9*
3.6	mean	366.1	68.0	497.7	15.5	61.2	288.8	25.0	222.8	16965	104.5
	replicates	*408.9, 323.2*	*68.9, 67.0*	*520.8, 474.6*	*14.2, 16.7*	*61.1, 61.3*	*285.6, 291.9*	*25.4, 24.7*	*230.4, 215.2*	*16398, 17532*	*102.1, 107.0*
3.7	mean	326.5	52.7	56.4	13.6	60.8	276.6	19.0	233.3	20488	86.8
	replicates	*368.0, 285.0*	*54.7, 50.6*	*74.9, 37.9*	*15.4, 11.8*	*63.3, 58.3*	*292.9, 260.2*	*19.6, 18.5*	*231.0, 235.6*	*21246, 19730*	*95.7, 77.8*
3.8	mean	381.8	56.3	227.8	14.7	67.4	383.8	23.4	238.6	26631	95.6
	replicates	*419.9, 343.8*	*56.6, 56.0*	*230.8, 224.9*	*14.8, 14.5*	*66.7, 68.0*	*362.9, 404.6*	*22.5, 24.2*	*224.4, 252.8*	*24619, 28643*	*98.1, 93.1*
3.9	mean	330.6	53.8	172.4	12.2	61.3	298.3	20.9	213.3	20030	84.6
	replicates	*366.3, 295.0*	*55.4, 52.2*	*197.8, 147.0*	*13.7, 10.8*	*63.9, 58.7*	*316.5, 280.1*	*21.8, 20.0*	*227.2, 199.5*	*20448, 19613*	*93.4, 75.8*
3.10	mean	273.5	51.7	ND	14.3	63.9	287.2	21.5	225.0	8401	105.6
	replicates	*228.7, 318.4*	*52.1, 51.3*	*ND, ND*	*14.7, 13.9*	*64.4, 63.3*	*284.1, 290.4*	*21.5, 21.4*	*233.7, 216.3*	*6611, 10190*	*107.6, 103.6*
3.11	mean	337.9	47.8	ND	13.9	60.2	402.1	15.4	203.5	30132	100.1
	replicates	*384.8, 291.0*	*48.2, 47.4*	*ND, ND*	*14.7, 13.1*	*62.0, 58.3*	*426.4, 377.7*	*16.0, 14.8*	*217.4, 189.7*	*30832, 29432*	*108.0, 92.2*
3.12	mean	335.9	47.5	ND	14.2	60.8	356.0	15.1	212.7	26177	96.8
	replicates	*383.1, 288.8*	*48.1, 46.9*	*ND, ND*	*14.9, 13.5*	*61.7, 59.9*	*355.5, 356.5*	*15.7, 14.6*	*219.7, 205.6*	*25941, 26414*	*103.0, 90.5*

3.13*	mean	330.5	49.6	0.0	12.4	59.9	267.6	17.2	221.0	18856	96.7
	replicates										
3.14	mean	335.7	48.3	0.0	12.8	58.3	346.2	18.1	221.5	24471	90.1
	replicates	*371.4, 300.0*	*49.0, 47.5*	*ND, ND*	*13.3, 12.3*	*58.6, 57.9*	*356.6, 335.8*	*19.5, 16.7*	*228.2, 214.8*	*24678, 24264*	*93.7, 86.6*
3.15	mean	346.4	50.5	0.0	13.3	62.5	259.2	20.3	207.8	20655	102.1
	replicates	*376.7, 316.2*	*51.3, 49.6*	*ND, ND*	*13.9, 12.8*	*62.5, 62.5*	*260.9, 257.5*	*21.0, 19.7*	*209.8, 205.8*	*20714, 20596*	*111.1, 93.1*
3.16	mean	350.5	55.8	126.0	13.1	67.3	206.1	23.4	243.2	13127	97.5
	replicates	*364.5, 336.5*	*55.6, 55.9*	*122.7, 129.2*	*13.8, 12.4*	*66.0, 68.6*	*206.9, 205.4*	*23.4, 23.4*	*231.8, 254.7*	*13211, 13043*	*98.6, 96.3*
3.17	mean	342.4	62.3	340.6	13.0	62.2	342.0	20.8	227.4	21798	90.9
	replicates	*366.3, 318.6*	*66.7, 58.0*	*346.4, 334.9*	*13.9, 12.0*	*62.4, 62.1*	*342.2, 341.9*	*20.7, 20.9*	*221.9, 232.8*	*19134, 24461*	*96.8, 84.9*
3.18	mean	310.9	56.0	297.6	11.4	58.4	317.8	19.6	207.2	20822	82.8
	replicates	*347.3, 274.4*	*56.2, 55.7*	*299.8, 295.4*	*12.2, 10.6*	*58.6, 58.2*	*319.2, 316.4*	*19.7, 19.6*	*206.9, 207.4*	*20339, 21306*	*87.9, 77.7*
3.19	mean	324.9	51.7	165.0	11.9	59.7	409.9	19.2	226.7	33781	89.8
	replicates	*362.3, 287.5*	*51.7, 51.7*	*161.1, 169.0*	*12.7, 11.2*	*59.8, 59.6*	*399.5, 420.3*	*19.4, 19.1*	*230.2, 223.2*	*31601, 35960*	*99.1, 80.4*
3.20	mean	283.3	53.5	313.2	9.4	52.7	367.7	20.0	187.7	24747	78.4
	replicates	*340.0, 226.5*	*54.5, 52.6*	*341.6, 284.8*	*10.7, 8.1*	*55.5, 49.9*	*385.8, 349.6*	*21.7, 18.3*	*191.6, 183.9*	*24580, 24915*	*90.4, 66.4*
3.21	mean	311.6	53.6	116.3	10.7	61.5	221.6	21.5	233.3	17164	88.3
	replicates	*341.3, 281.9*	*54.1, 53.1*	*125.4, 107.3*	*11.1, 10.3*	*62.3, 60.8*	*229.1, 214.1*	*21.4, 21.5*	*229.8, 236.8*	*17599, 16728*	*92.8, 83.8*
3.22	mean	338.5	51.7	ND	11.9	61.5	302.1	21.1	223.8	24540	92.5
	replicates	*357.4, 319.5*	*52.7, 50.8*	*ND, ND*	*12.6, 11.3*	*61.1, 62.0*	*307.2, 297.0*	*21.3, 20.9*	*218.9, 228.8*	*25586, 23495*	*96.5, 88.6*
3.23	mean	328.4	54.9	99.5	12.3	59.5	373.4	20.7	209.5	26700	94.0
	replicates	*351.7, 305.1*	*53.6, 56.1*	*84.2, 114.8*	*13.1, 11.5*	*59.8, 59.3*	*380.3, 366.4*	*21.0, 20.4*	*213.3, 205.6*	*26690, 26710*	*96.2, 91.8*
3.24	mean	319.1	51.5	ND	13.3	57.6	311.6	20.3	214.1	20562	88.4
	replicates	*351.9, 286.4*	*52.3, 50.7*	*ND, ND*	*13.6, 13.1*	*57.7, 57.5*	*313.9, 309.3*	*20.0, 20.7*	*220.5, 207.7*	*21089, 20035*	*90.9, 85.9*
3.25	mean	325.8	55.3	115.8	12.3	63.9	157.4	22.3	237.9	10981	92.5
	replicates	*359.9, 291.6*	*56.7, 53.9*	*132.2, 99.5*	*13.4, 11.3*	*65.6, 62.2*	*164.8, 149.9*	*22.8, 21.8*	*235.9, 239.9*	*11633, 10329*	*99.1, 85.8*
3.26	mean	312.5	53.3	137.1	10.9	59.9	270.9	20.7	218.3	19598	85.5
	replicates	*352.1, 272.9*	*54.6, 51.9*	*158.2, 116.1*	*12.1, 9.8*	*62.1, 57.6*	*302.1, 239.8*	*21.2, 20.1*	*229.1, 207.4*	*21917, 17278*	*94.3, 76.8*
3.27	mean	296.8	53.6	127.5	11.4	59.4	291.6	22.3	219.4	20228	95.8

	replicates	*345.1, 248.6*	*55.3, 51.8*	*147.4, 107.5*	*12.8, 10.1*	*61.0, 57.7*	*263.2, 319.9*	*21.7, 22.8*	*217.6, 221.3*	*18203, 22252*	*97.8, 93.8*
3.28	mean	322.8	53.2	84.2	12.2	61.7	257.8	21.3	233.7	17884	96.9
	replicates	*350.6, 295.0*	*54.2, 52.2*	*91.7, 76.7*	*13.0, 11.4*	*61.9, 61.5*	*254.2, 261.4*	*21.4, 21.1*	*218.4, 249.1*	*17974, 17793*	*99.5, 94.3*
3.29	mean	312.3	50.6	ND	10.8	56.9	392.0	19.2	207.9	28613	77.4
	replicates	*339.6, 285.0*	*51.2, 50.1*	*ND, ND*	*11.3, 10.4*	*56.3, 57.5*	*395.1, 389.0*	*18.6, 19.9*	*201.2, 214.7*	*29807, 27420*	*79.2, 75.6*
3.30	mean	335.1	48.1	ND	11.6	58.4	463.5	16.7	206.7	38808	87.7
	replicates	*376.6, 293.6*	*49.3, 46.9*	*ND, ND*	*13.0, 10.3*	*59.5, 57.3*	*483.7, 443.3*	*17.3, 16.2*	*212.0, 201.4*	*40747, 36868*	*95.1, 80.2*
3.31	mean	294.4	63.7	1074	13.7	46.8	256.8	26.6	174.0	18251	106.4
	replicates	*323.0, 265.8*	*65.4, 61.9*	*1103, 1044*	*14.1, 13.4*	*48.0, 45.5*	*259.3, 254.2*	*27.1, 26.2*	*172.5, 175.5*	*18682, 17820*	*111.8, 101.0*
3.32	mean	339.8	56.4	199.5	12.3	63.8	323.7	22.3	238.7	23939	88.7
	replicates	*367.6, 312.0*	*57.3, 55.6*	*205.0, 194.1*	*13.1, 11.6*	*63.3, 64.3*	*314.4, 333.0*	*22.0, 22.6*	*227.0, 250.5*	*23771, 24106*	*90.9, 86.5*
3.33	mean	322.5	52.6	144.0	10.9	60.5	261.9	20.7	230.2	20631	86.2
	replicates	*361.2, 283.7*	*53.5, 51.7*	*159.6, 128.3*	*12.6, 9.2*	*62.1, 58.9*	*279.4, 244.3*	*20.9, 20.5*	*224.8, 235.6*	*21286, 19976*	*91.7, 80.7*
3.34	mean	324.1	53.6	123.0	11.9	61.7	227.9	21.5	228.2	16170	89.0
	replicates	*341.8, 306.4*	*53.5, 53.7*	*123.0, 123.1*	*11.7, 12.0*	*61.4, 62.1*	*224.5, 231.3*	*21.0, 22.1*	*236.7, 219.8*	*16515, 15826*	*90.9, 87.1*
3.35	mean	313.3	54.1	ND	12.6	62.0	190.6	22.1	230.0	13862	91.2
	replicates	*364.3, 262.3*	*57.0, 51.2*	*ND, ND*	*13.4, 11.8*	*64.8, 59.3*	*187.5, 193.8*	*22.2, 22.1*	*232.5, 227.6*	*13392, 14331*	*100.4, 81.9*
3.36	mean	318.0	54.3	117.8	11.5	60.6	265.6	22.1	216.8	19078	85.4
	replicates	*349.5, 286.6*	*55.0, 53.5*	*127.7, 108.0*	*11.8, 11.2*	*62.0, 59.3*	*246.3, 284.8*	*22.6, 21.6*	*223.6, 210.1*	*18327, 19828*	*87.8, 83.1*
Mean		**327.1**	**53.7**	**142.2**	**12.4**	**60.8**	**295.0**	**20.9**	**220.5**	**21017**	**91.3**
SD		**20.9**	**4.2**	**196.4**	**1.3**	**3.7**	**69.1**	**2.4**	**14.5**	**5950**	**7.8**

(b)

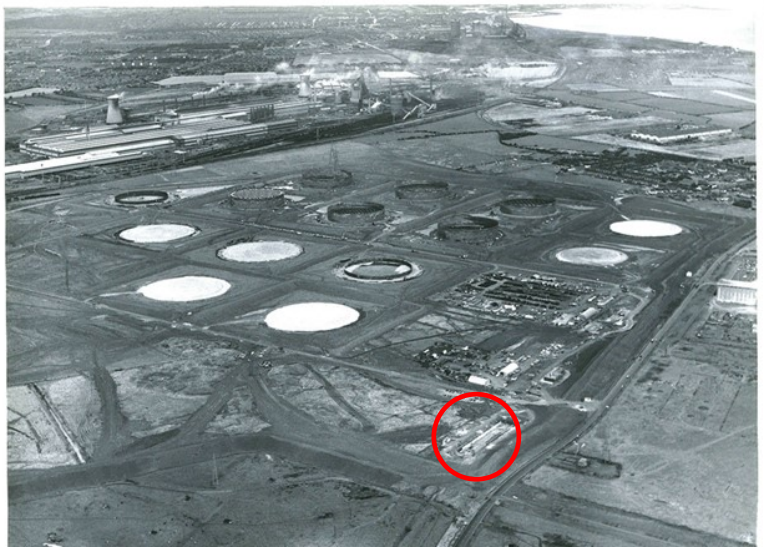
SAMPLE[@]		V	Ni	Zn	As	Rb	Sr	Y	Zr	Ba	Pb
1.1	mean	311.9	58.2	517.5	7.8	69.1	118.1	22.9	169.6	5097	61.4
	replicates	*349.9, 273.8*	*60.6, 55.8*	*525.7, 509.2*	*8.9, 6.6*	*70.6, 67.7*	*121.6, 114.5*	*23.1, 22.7*	*177.7, 161.5*	*5020, 5173*	*68.1, 54.8*
1.2	mean	293.0	56.2	260.9	7.6	64.8	86.6	20.5	198.0	3409	62.4
	replicates	*318.4, 267.6*	*57.3, 55.1*	*280.4, 241.4*	*8.4, 6.8*	*65.3, 64.3*	*91.1, 82.1*	*21.5, 19.6*	*207.6, 188.3*	*3345, 3473*	*68.6, 56.2*
1.3	mean	425.3	59.5	125.5	44.0	87.5	97.4	24.0	191.9	3261	325.7
	replicates	*451.7, 399.0*	*60.7, 58.2*	*136.8, 114.3*	*44.9, 43.1*	*90.3, 84.8*	*99.8, 94.9*	*24.6, 23.5*	*198.6, 185.1*	*3160, 3363*	*328.3, 323.2*
1.4	mean	394.8	56.7	94.5	34.6	84.6	93.4	24.6	204.8	3475	239.5
	replicates	*419.7, 369.8*	*57.3, 56.0*	*102.2, 86.8*	*36.5, 32.7*	*86.0, 83.2*	*94.6, 92.2*	*24.6, 24.6*	*207.2, 202.3*	*3481, 3469*	*243.6, 235.4*
1.5	mean	398.7	58.7	ND	28.2	89.6	92.3	24.4	210.5	3239	185.0
	replicates	*417.9, 379.5*	*58.8, 58.6*	*ND, ND*	*27.5, 28.9*	*90.5, 88.8*	*92.5, 92.0*	*24.3, 24.5*	*209.4, 211.6*	*3170, 3308*	*184.7, 185.4*
1.6	mean	381.4	55.8	79.9	28.1	86.3	98.2	25.4	233.8	3333	203.5
	replicates	*383.3, 379.5*	*56.3, 55.3*	*84.8, 75.0*	*29.2, 27.0*	*87.5, 85.1*	*99.6, 96.8*	*25.9, 24.9*	*238.3, 229.3*	*3371, 3296*	*209.4, 197.5*
1.7	mean	360.1	64.4	655.0	11.5	80.6	122.4	25.2	164.5	4644	70.5
	replicates	*381.3, 338.9*	*65.1, 63.7*	*668.9, 641.1*	*12.2, 10.8*	*81.1, 80.1*	*124.0, 120.8*	*25.4, 25.0*	*167.8, 161.2*	*4631, 4657*	*73.9, 67.1*
1.8	mean	460.3	66.5	375.7	21.8	90.7	109.8	25.6	168.5	3596	152.1
	replicates	*460.3, 460.3*	*67.7, 65.3*	*387.4, 363.9*	*22.4, 21.3*	*91.9, 89.4*	*111.5, 108.1*	*25.9, 25.3*	*168.5, 168.5*	*3534, 3657*	*154.0, 150.3*
1.9	mean	375.6	58.6	125.1	9.0	84.2	111.1	24.5	191.2	4106	63.6
	replicates	*375.6, 375.6*	*60.1, 57.0*	*133.4, 116.7*	*9.6, 8.4*	*85.3, 83.2*	*115.0, 107.2*	*24.5, 24.6*	*196.5, 185.9*	*4091, 4122*	*75.6, 51.7*
Mean		**377.9**	**59.4**	**254.8**	**21.4**	**81.9**	**103.2**	**24.1**	**192.5**	**3796**	**151.5**
SD		**52.1**	**3.7**	**215.6**	**13.2**	**9.1**	**12.5**	**1.6**	**22.6**	**672**	**95.0**

* Only one replicate
ND = <LOQ
# Data corrected using CRM calibration equation
@ Duplicate samples were determined by two different individuals on different occasions, but within one month of each other.
Site A: Conoco Phillips, Main Site Teesside Terminal, Seal Sands. A 285 acre site investigating the middle (number 3) of 5 available beds.
Site B: Greatham Oil Storage Depot, Greatham. A 375 acres site investigating the periphery of the accessible area.

Figure S1. Sampling locations: Site A Main Site Teesside Refinery and B Greatham Storage Depot, (a) photograph of the main site (Site A) pre-development, in 1969, (b) photograph of Greatham Storage Deport (Site B), 1974, (c) aerial photograph of Main Site (Site A), sampling area highlighted, (d) aerial photograph of Storage Depot (Site B), sampling area highlighted, (e) ground-based photograph of sampling locations at Main Site (Site A), and (f) ground-based photograph of sampling locations at the Storage Depot (Site B).

(a)

(b)



(c)

(d)

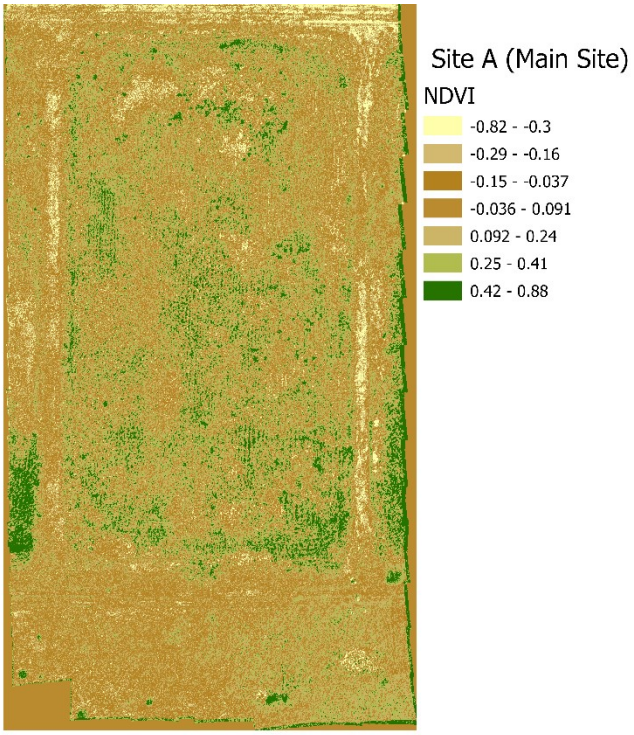
(e)

(f)

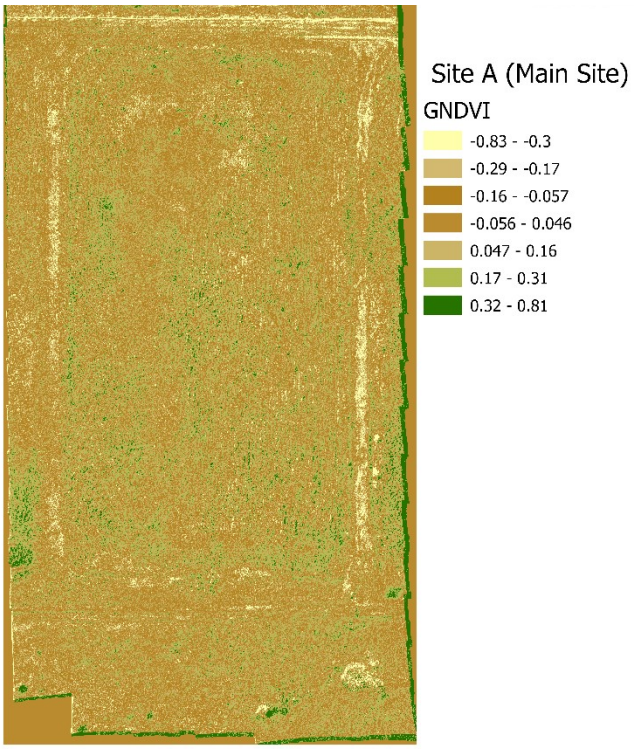
[Note: photographs (a)-(d) courtesy of Mr Tony J. Finn, Environment Engineer, Conoco Phillips, Teesside Operations, Seal Sands, Middlesbrough.]

Figure S2. Vegetation index maps for an area of Site A (Main Site) (a) NDVI (b) GNDVI (c) SAVI and (d) CI green VI.

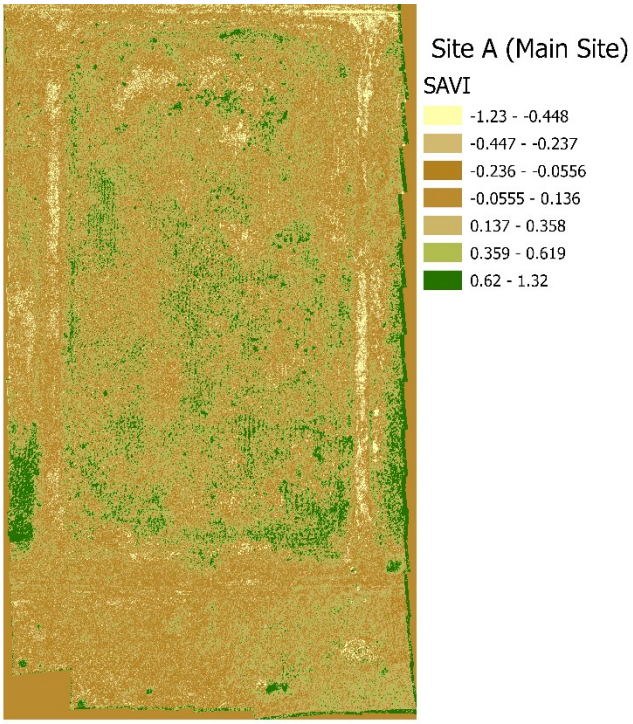
(a)



(b)



(c)


Site A (Main Site)
SAVI
-1.23 - -0.448
-0.447 - -0.237
-0.236 - -0.0556
-0.0555 - 0.136
0.137 - 0.358
0.359 - 0.619
0.62 - 1.32

(d)

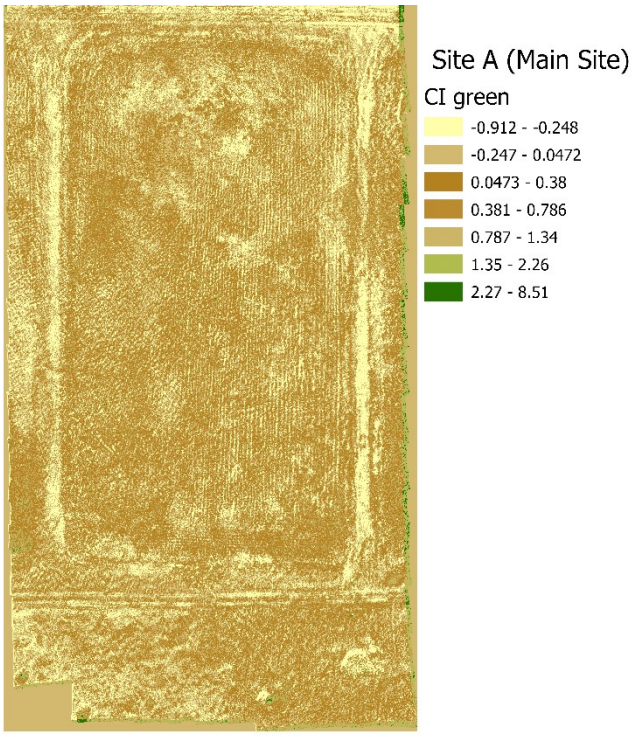
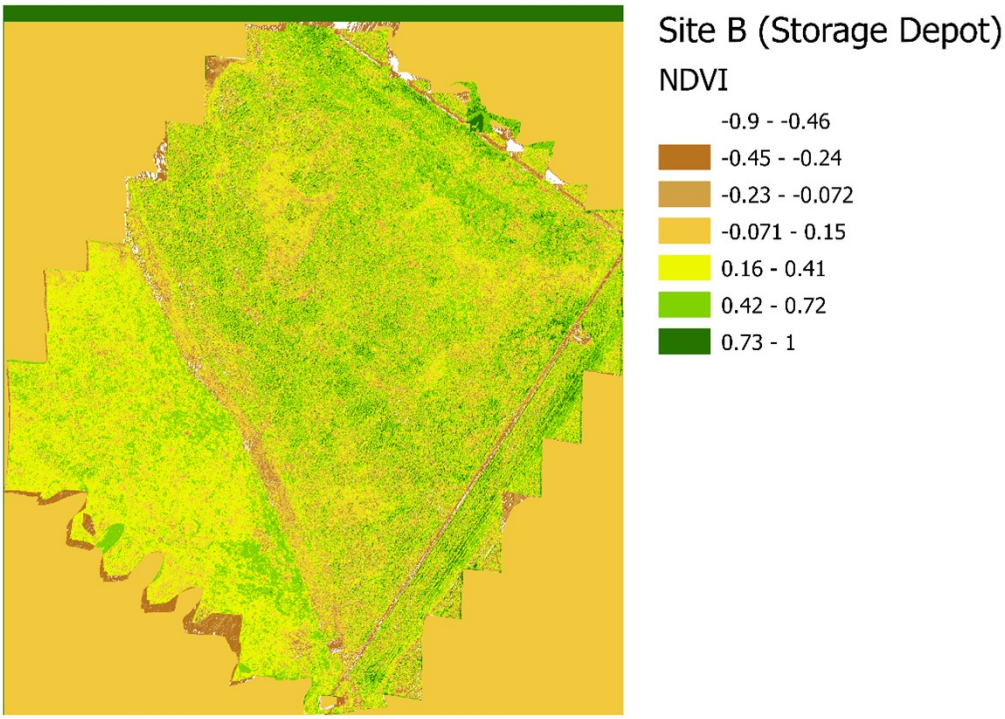
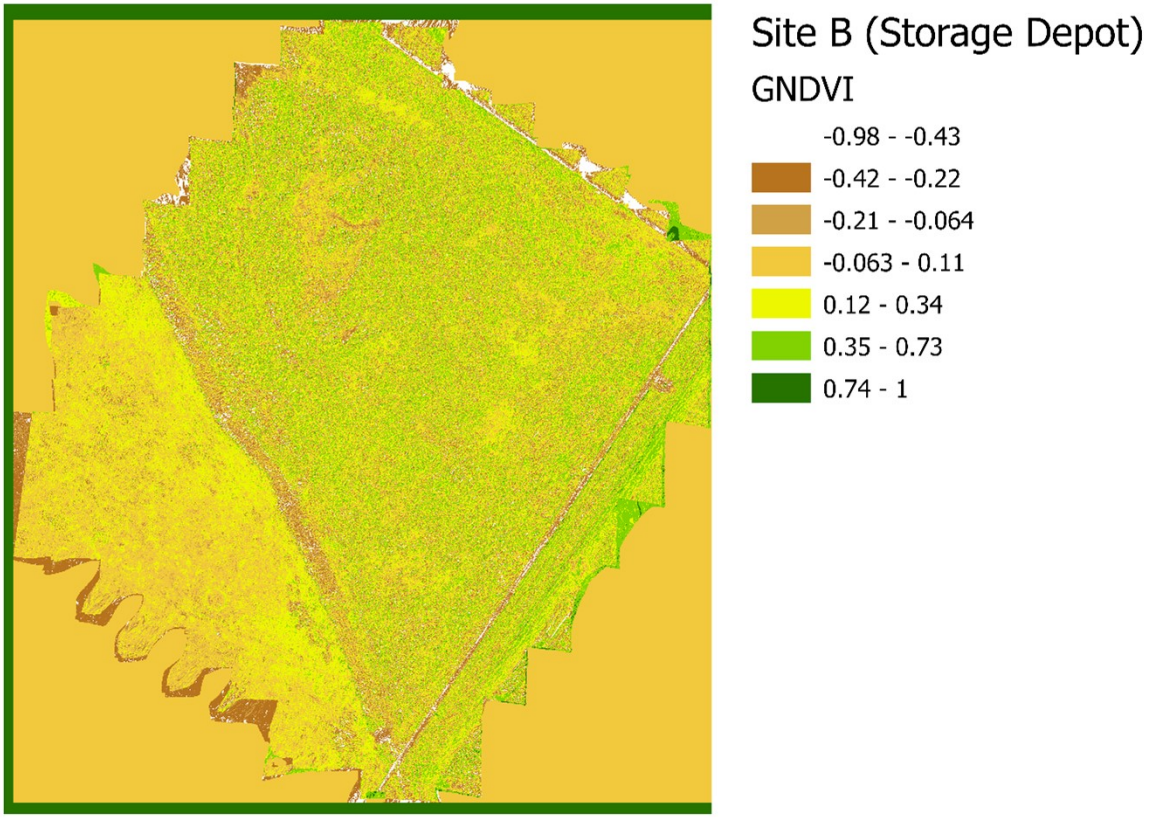

Site A (Main Site)
CI green
-0.912 - -0.248
-0.247 - 0.0472
0.0473 - 0.38
0.381 - 0.786
0.787 - 1.34
1.35 - 2.26
2.27 - 8.51

Figure S3. Vegetation index maps for an area of Site B (Storage Depot) (a) NDVI (b) GNDVI (c) SAVI and (d) CI green VI.

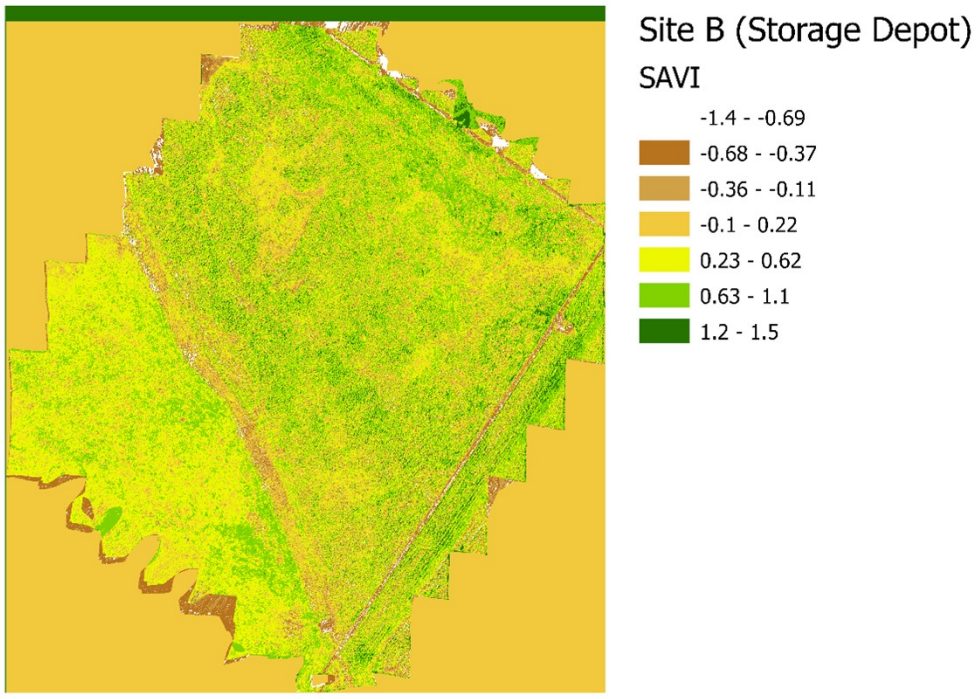
(a)



(b)



(c)


Site B (Storage Depot)
SAVI
-1.4 - -0.69
-0.68 - -0.37
-0.36 - -0.11
-0.1 - 0.22
0.23 - 0.62
0.63 - 1.1
1.2 - 1.5

(d)

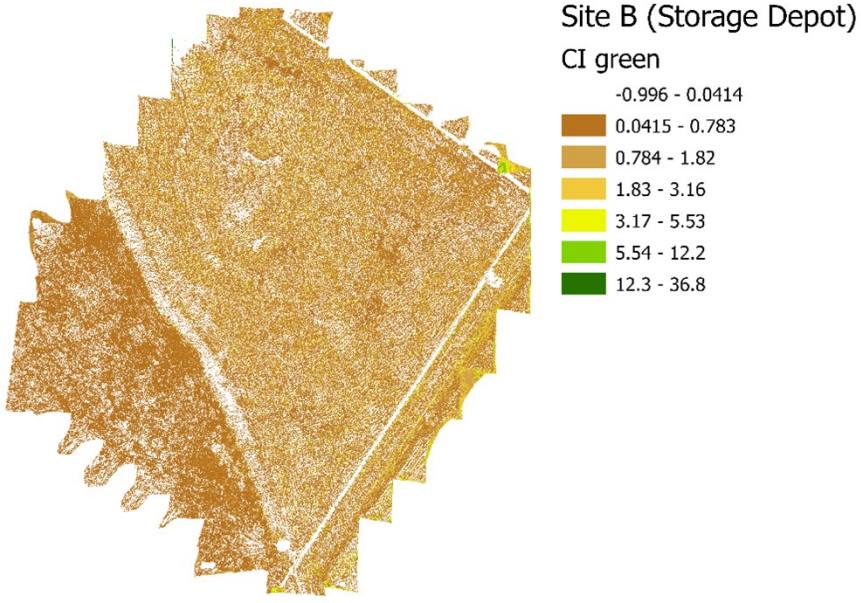
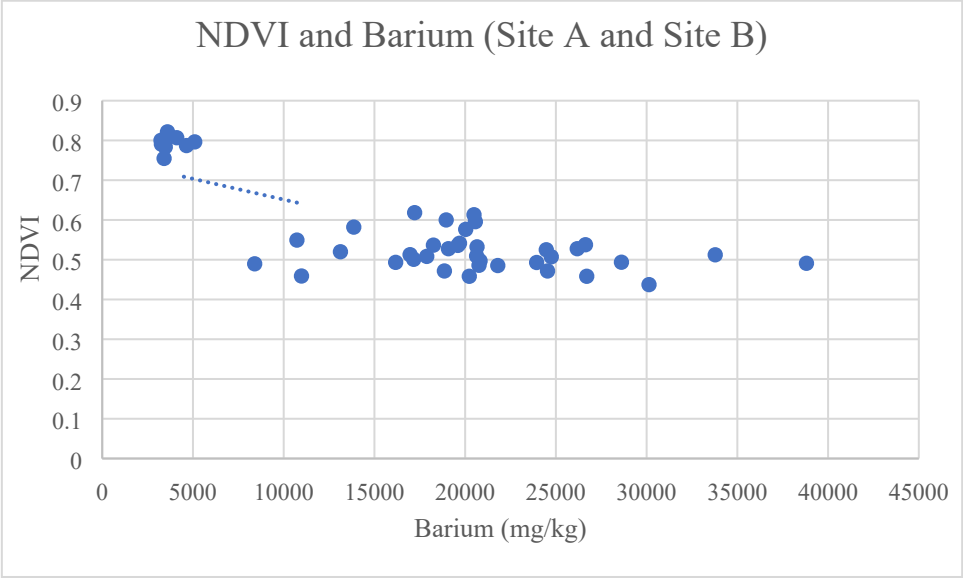
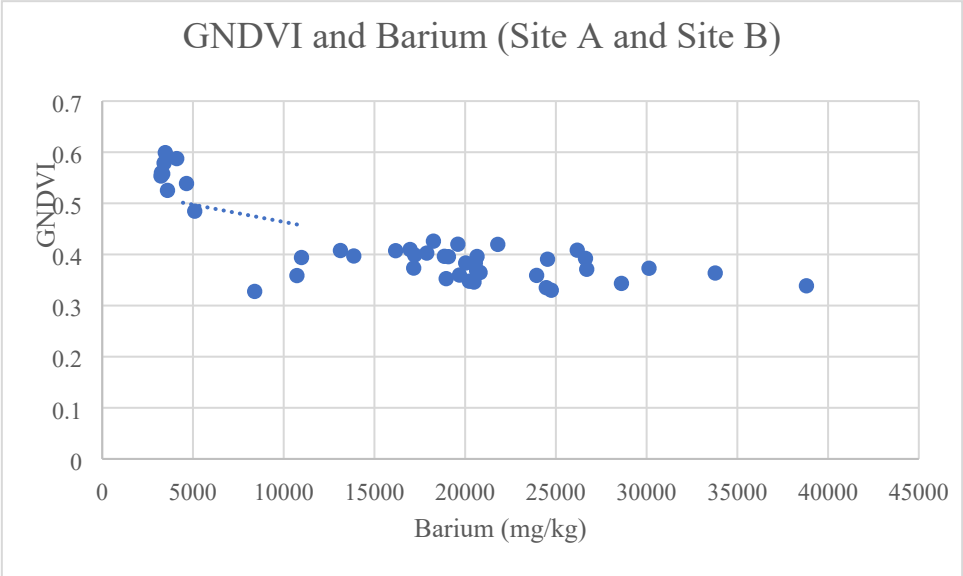

Site B (Storage Depot)
CI green
-0.996 - 0.0414
0.0415 - 0.783
0.784 - 1.82
1.83 - 3.16
3.17 - 5.53
5.54 - 12.2
12.3 - 36.8

Figure S4: Relationship between VI and barium in Site A and Site B (a) NDVI and barium (b) GNDVI and barium (c) SAVI and barium and (d) CI green VI and barium

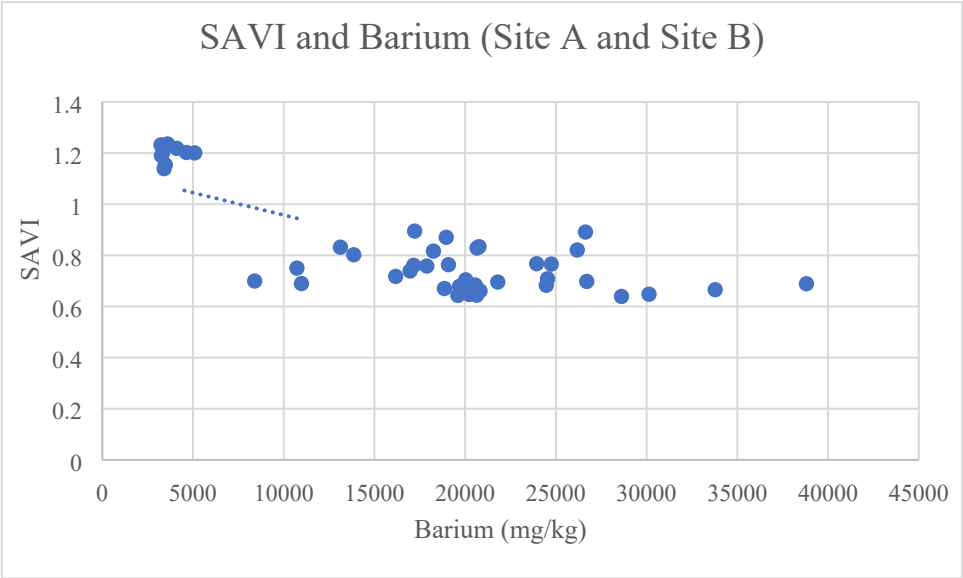
(a)



(b)



(c)


SAVI and Barium (Site A and Site B)
SAVI
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
Barium (mg/kg)

(d)

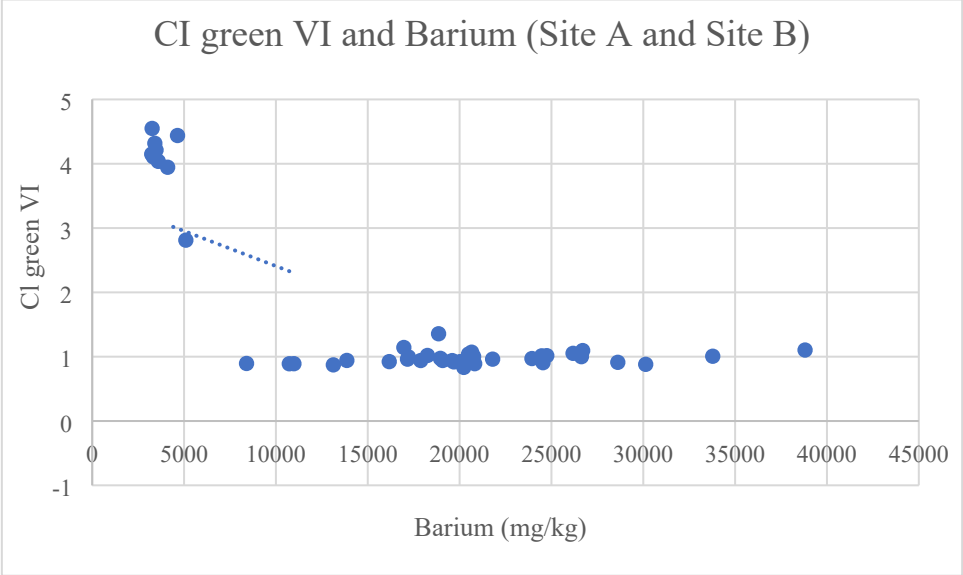
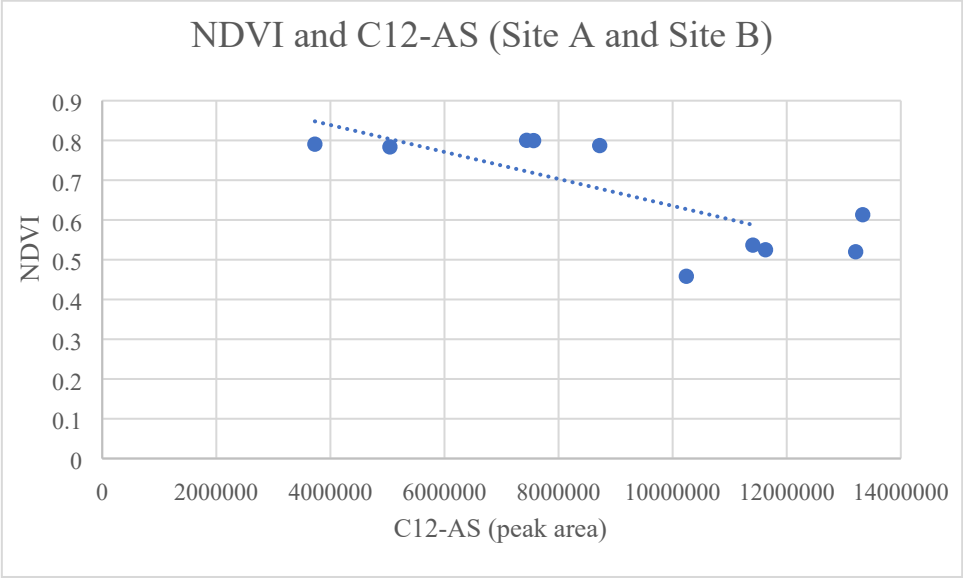
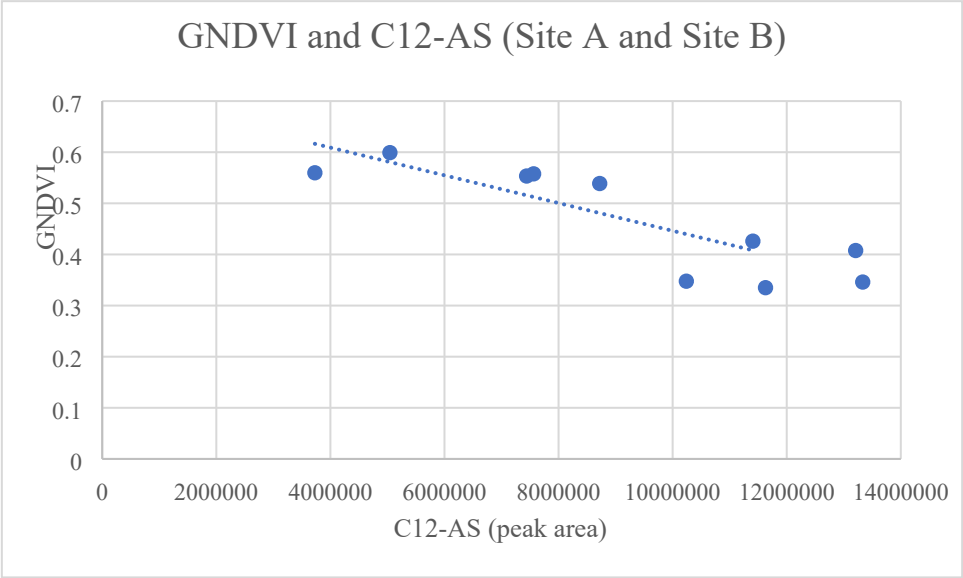

CI green VI and Barium (Site A and Site B)
Cl green VI
5
4
3
2
1
0
-1
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
Barium (mg/kg)

Figure S5: Relationship between VI and C12-AS in Site A and Site B (a) NDVI and C12-AS (b) GNDVI and C12-AS (c) SAVI and C12-AS and (d) CI green VI and C12-AS

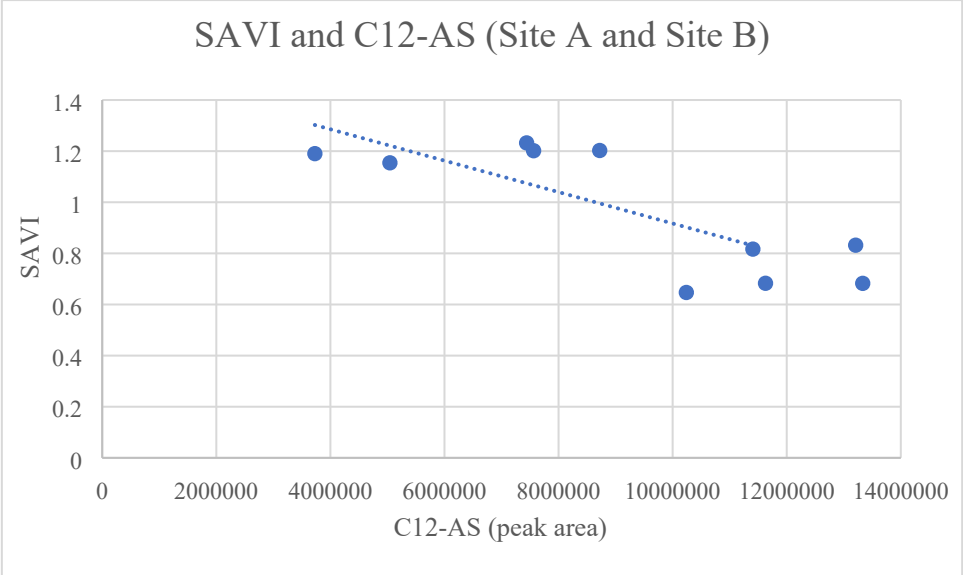
(a)



(b)



(c)


SAVI and C12-AS (Site A and Site B)
SAVI
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2000000
4000000
6000000
8000000
10000000
12000000
14000000
C12-AS (peak area)

(d)

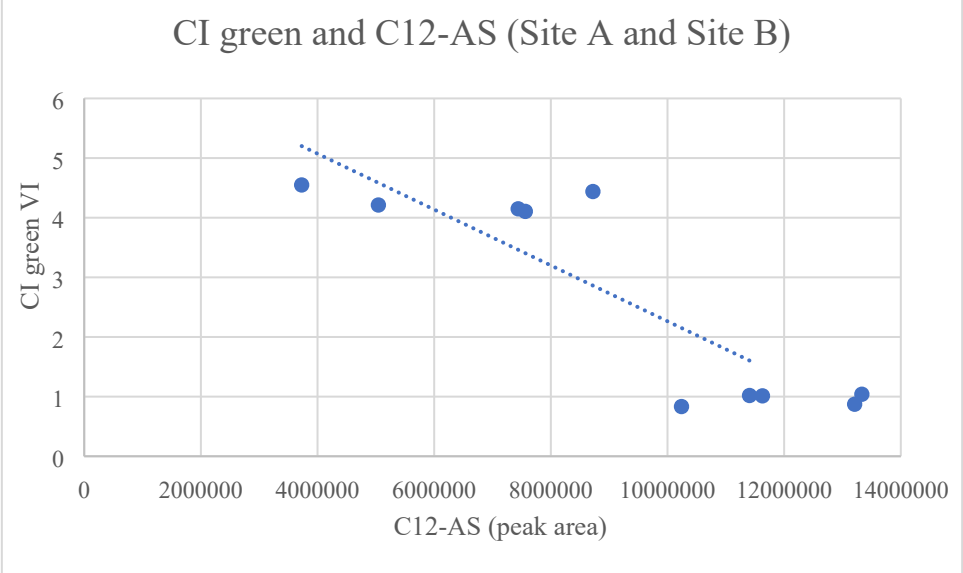
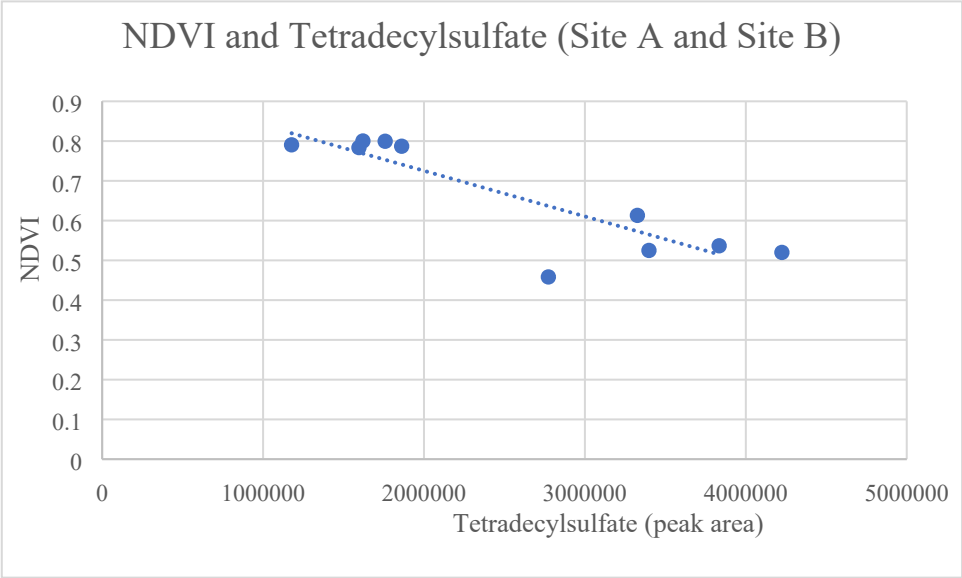
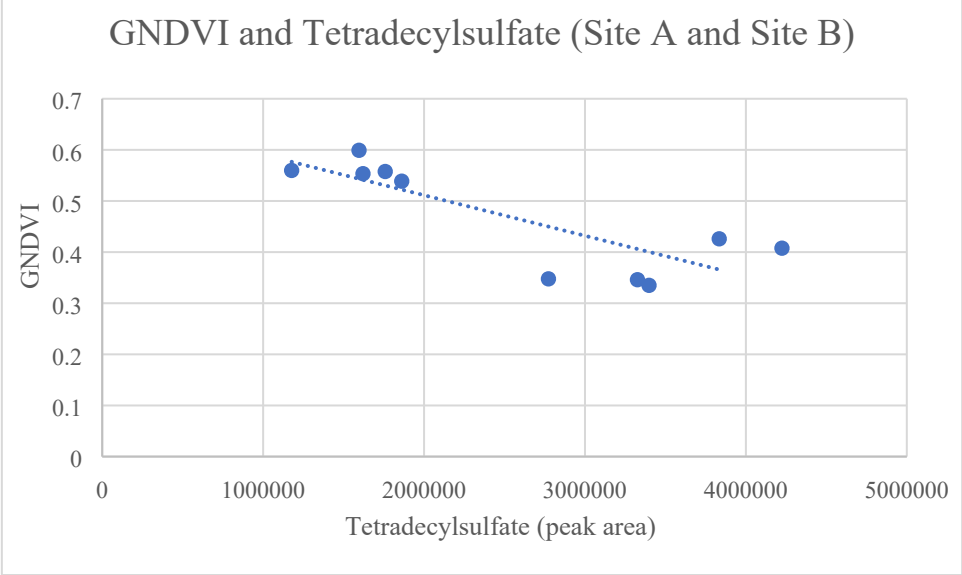

CI green and C12-AS (Site A and Site B)
CI green VI
6
5
4
3
2
1
0
0
2000000
4000000
6000000
8000000
10000000
12000000
14000000
C12-AS (peak area)

Figure S6. Relationship between VI and tetradecylsulfate in Site A and Site B (a) NDVI and tetradecylsulfate in (b) GNDVI and tetradecylsulfate in (c) SAVI and tetradecylsulfate in and (d) CI green VI and tetradecylsulfate

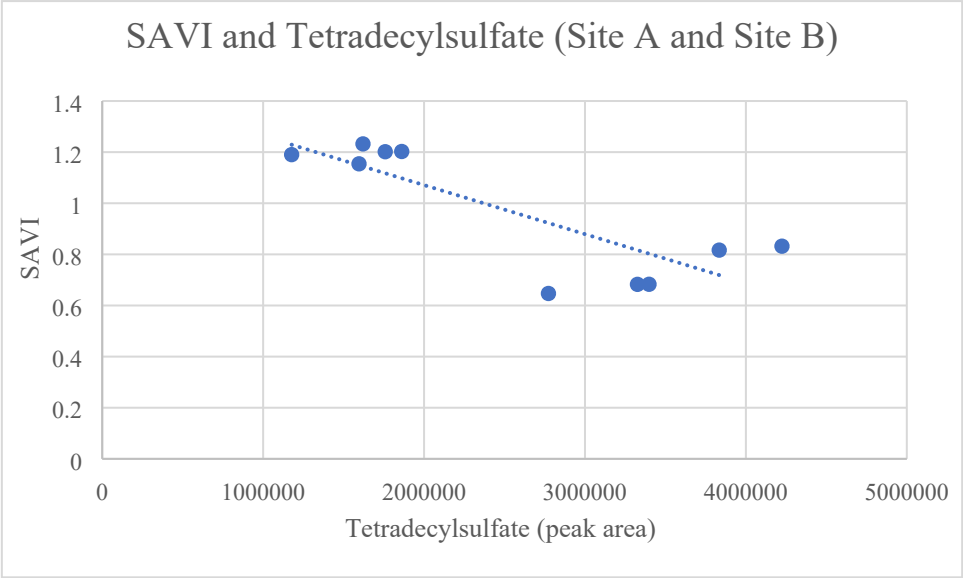
(a)



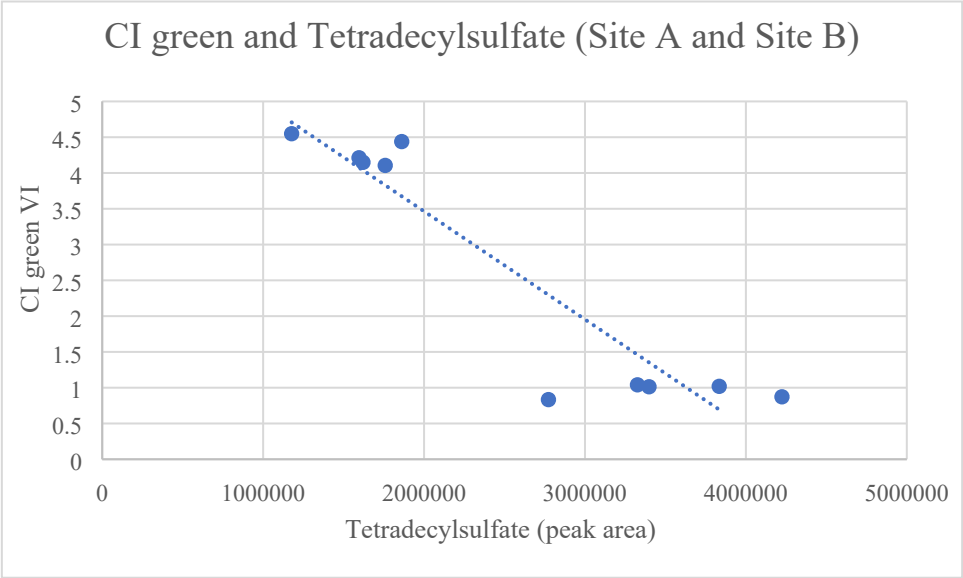
(b)



(c)


SAVI and Tetradecylsulfate (Site A and Site B)
SAVI
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
1000000
2000000
3000000
4000000
5000000
Tetradecylsulfate (peak area)

(d)


CI green and Tetradecylsulfate (Site A and Site B)
CI green VI
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1000000
2000000
3000000
4000000
5000000
Tetradecylsulfate (peak area)