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APPENDICES

APPENDIX A

1. Calculation of heavy metals solution for adding into the uncontaminated soil

The heavy metal solution was calculated by this formula:

$$\frac{C \times S \times MW}{AW \times 1{,}000}$$

When; C = Concentration of heavy metal (mg/kg soil)

S = Soil weight (kg)

AW = Atomic weight (g); Cd = 112.4, Zn = 63.37, Pb = 207.19 and Cu = 63.54

MW = Molecular weight (g); $Cd(NO_3)_2.4H_2O$ = 308.47, $ZnSO_4.7H_2O$ = 287.54, $Pb(NO_3)_2$ = 331.2 and $CuSO_4.5H_2O$ = 249.68

Example of calculation;

The Cd concentration was 100 mg/kg in 5 kg soil/pot.

Solution:

The amount of $Cd(NO_3)_2.4H_2O$ is:

[(100 mg Cd)(5 kg soil)(308.47 g of MW)]/[(112.4 g of AW)(1000)]

= 1.3722 g Cd

The amount of $Cd(NO_3)_2.4H_2O$ was 1.3722 g dissoluble in 100 mL of deionized water in 5 kg soil/pot.

APPENDIX B

SAMPLE ANALYSIS

1. USEPA 3052 method

1.1 Analysis of total metals in soil samples

A representative sample of 0.5 g was digested in 9 ml HCl (37%) and 3 ml HNO_3 (65%). The sample and acid were placed in suitably inert polymeric microwave vessels then the vessels were sealed and heated in the microwave system. The step of temperature and time in the Microwave Digestion System is presented in Table B.1. After cooling, the sample was filtrated using Whatman filter paper No. 40 (Ø 110 mm). All samples were made up to 50 ml by deionized water and preserved at 4 °C until analysis.

Table B.1 Temperature and time used for soil and fertilizer digestion

Step	Time (min)	Temperature (°C)
1	10	200
2	15	200

1.2 Analysis of total metals in *C. odorata* samples

A representative of 0.5 g of roots, stems and leaves was digested in 9 ml HNO_3 (65%). Sample and acid were placed in an inert vessel then the vessels were sealed and heated in the microwave system. The step of temperature and time in the Microwave Digestion System is presented in Table B.2. After cooling, the sample was filtrated using Whatman filter paper No. 40 (Ø 110 mm.). All samples were made up to 25 ml by deionized water and preserved at 4 °C until analysis.

Table B.2 Temperature and time used for *C. odorata* sample digestion

Step	Time (min)	Temperature (°C)
1	5	180
2	10	180

1.3 Analysis of total metals in *V. zizanioides* samples

A representative of 0.5 g of roots, stems and leaves was digested in 8 ml HNO_3 (65%) and 2 ml H_2O_2 (30%). Sample and acid were placed in an inert vessel then the vessels were sealed and heated in the microwave system. The steps of temperature and time in the Microwave Digestion System are presented in Table B.3. After cooling, the sample was filtrated using Whatman filter paper No. 40 (Ø 110 mm.). All samples were made up to 25 ml by deionized water and preserved at 4 °C until analysis.

Table B.3 Temperature and time used for *V. zizanioides* sample digestion

Step	Time (min)	Temperature (°C)
1	3	85
2	9	145
3	4	200
4	14	200

2. DTPA extraction method

Ten gram sub-samples of air-dried soil were placed in Erlenmeyer flasks with DTPA extracted solution (0.005 M DTPA, 0.01 M $CaCl_2$ and 0.1 M TEA) and sealed with parafilm. Each flask was shaken for 2 hour at 120 rpm. After that, sample was filtrated using Buchner's funnel and vacuum pump with GF/C (Glass Micro Filters) filter paper (Ø 70 mm.). The sample was stored in polyethylene containers stored at 4 °C for analysis.

2.1 Preparation for DTPA extractant: 0.005 mol/L DTPA

The DTPA extracting solution was prepared containing 0.005 mol/l diethylenetriamine-pentaacetic acid (DTPA) [$C_{14}H_{23}N_3O_{10}$], 0.01 mol/l triethanolamine (TEA) [$(HOCH_2CH_2)_3N$] and adjusted to pH 7.3. To prepare 10 L of this solution required 149.2 g reagent grade TEA, 19.67 g DTPA and 14.7 g calcium chloride [$CaCl_2.2H_2O$] in approximately 200 mL distilled water. Sufficient time was provided for the DTPA to dissolve and dilute to approximately 9 L. The pH was adjusted to 7.3+0.5 with HCl while stirring and diluted to 10 L. This solution was stable for several months.

2.2 Calculation of heavy metals in DTPA

$$\text{Amount of heavy metal (mg/L)} = (\text{mg/L in soil} - \text{mg/L in blank}) \times \frac{\text{amount of DTPA extracting solution (mL)}}{\text{Weight of soil (g)}}$$

APPENDIX C

1. Heavy metals removal from contaminated soil by using *C. odorata* and *V. zizanioides*

1.1 Concentration of total heavy metals in contaminated soil

Table C.1 Concentration of total heavy metals in contaminated soil of *C. odorata* pot

Metal	Concentration of total heavy metals in contaminated soil (mg/kg)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	43.849	44.027	39.698	43.410	41.754	42.728	42.003	42.245
	44.197		45.724		43.628		41.145	
	44.036		44.809		42.802		43.586	
Zn	1964.286	2014.238	2018.093	2010.657	1922.338	1990.273	1918.295	1976.538
	2070.476		1961.347		2023.065		1960.385	
	2007.952		2052.529		2025.417		2050.933	
Pb	86.679	85.671	82.593	84.942	81.315	83.766	85.769	82.939
	84.506		85.431		86.982		80.559	
	85.828		86.800		83.002		82.490	
Cu	23.810	23.919	23.446	23.564	21.660	23.297	21.722	23.074
	24.886		23.140		24.302		22.381	
	23.062		24.106		23.930		25.119	

Table C.2 Concentration of total heavy metals in contaminated soil of *V. zizanioides* pot

Metal	Concentration of total heavy metals in contaminated soil (mg/kg)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	42.888	42.472	43.282	42.089	43.015	41.912	40.842	41.775
	39.835		40.996		41.749		42.060	
	44.691		41.987		40.971		42.424	
Zn	2074.606	2045.255	1928.559	2009.296	1925.153	1986.579	2003.308	1979.456
	2001.570		2003.929		2034.198		1980.626	
	2059.588		2095.400		2000.387		1954.434	
Pb	77.059	81.007	80.335	80.756	81.695	80.379	81.488	80.058
	82.318		79.599		79.398		83.301	
	83.646		82.335		80.045		75.385	
Cu	23.639	24.488	25.363	23.834	23.814	23.864	23.390	23.578
	24.431		23.093		24.951		22.799	
	25.395		23.045		22.828		24.546	

1.2 Phytoavailability of heavy metals in contaminated soil by DTPA extraction method

Table C.3 Phytoavailability of heavy metals in contaminated soil of *C. odorata* pot

Metal	Phytoavailability of heavy metals in contaminated soil (mg/kg)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	6.294	5.431	4.349	4.929	3.744	4.915	4.513	4.694
	4.975		4.855		5.229		5.510	
	5.025		5.581		5.771		4.060	
Zn	250.582	218.833	173.546	218.481	198.505	204.559	158.666	201.330
	205.235		235.325		229.041		206.835	
	200.683		246.571		186.132		238.490	
Pb	7.237	6.970	6.310	6.489	6.388	6.430	4.858	5.773
	6.835		6.539		6.491		5.945	
	6.837		6.619		6.411		6.516	
Cu	2.173	2.188	2.269	2.095	1.989	2.052	1.991	2.032
	2.239		1.962		2.035		1.995	
	2.153		2.053		2.132		2.111	

Table C.4 Phytoavailability of heavy metals in contaminated soil of *V. zizanioides* pot

Metal	Phytoavailability of heavy metals in contaminated soil (mg/kg)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	6.066	5.515	5.790	5.220	4.992	4.655	5.445	3.869
	4.882		4.313		4.296		2.456	
	5.598		5.557		4.677		3.707	
Zn	244.847	221.245	238.723	219.524	206.741	201.282	224.990	174.051
	188.041		195.440		194.319		123.281	
	230.847		224.410		202.787		173.882	
Pb	7.205	6.815	6.822	6.488	6.123	6.277	6.908	5.833
	6.634		6.030		6.365		4.277	
	6.605		6.612		6.342		6.315	
Cu	2.155	2.081	2.074	2.068	2.196	2.042	2.094	2.039
	2.092		2.075		1.919		1.911	
	1.995		2.054		2.012		2.111	

1.3 Heavy metals concentration in various parts of plant in contaminated soil

Table C.5 Heavy metals concentration in roots of *C. odorata* in contaminated soil

Metal	Heavy metals concentration in roots of *C. odorata* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	14.818	15.703	32.496	36.738	60.067	50.218	17.977	16.053
	13.358		36.269		50.509		17.253	
	18.933		41.449		40.078		12.929	
Zn	88.974	123.445	95.106	98.520	58.556	66.696	94.455	88.229
	138.083		104.409		61.931		86.264	
	143.277		96.045		79.601		83.969	
Pb	13.904	11.379	16.819	29.074	14.699	20.380	18.586	23.769
	12.112		36.788		22.010		39.482	
	8.121		33.616		24.430		13.240	
Cu	32.392	31.889	27.809	25.434	18.523	18.648	7.617	9.408
	30.311		22.892		15.027		7.963	
	32.963		25.600		22.394		12.643	

Table C.6 Heavy metals concentration in roots of *V. zizanioides* in contaminated soil

Metal	Heavy metals concentration in roots of *V. zizanioides* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	2.848	3.238	2.947	3.618	6.281	7.018	9.731	11.243
	0.649		2.235		7.710		11.429	
	6.218		5.672		7.063		12.569	
Zn	108.175	111.053	99.191	85.406	86.057	126.615	176.107	163.180
	121.522		69.375		132.620		177.294	
	103.462		87.652		161.168		136.139	
Pb	10.718	16.321	21.564	23.996	37.438	26.507	35.940	40.630
	14.374		29.797		17.013		44.696	
	23.870		20.627		25.070		41.254	
Cu	3.715	5.668	8.051	7.138	15.204	15.617	9.731	12.335
	5.674		6.555		18.019		20.713	
	7.614		6.807		13.629		6.560	

Table C.7 Heavy metals concentration in stems of *C. odorata* in contaminated soil

Metal	Heavy metal concentration in stems of *C. odorata* (mg//kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	9.730	11.161	12.708	13.071	5.259	8.933	11.856	12.008
	10.964		10.784		10.183		10.857	
	12.790		15.721		11.356		13.309	
Zn	41.998	45.278	34.594	29.867	25.566	26.808	16.260	18.768
	43.955		21.307		25.808		21.618	
	49.882		33.699		29.049		18.425	
Pb	10.425	12.019	4.314	4.839	8.010	8.599	13.550	12.129
	12.940		4.575		9.639		9.080	
	12.692		5.627		8.147		13.756	
Cu	1.355	1.794	8.091	6.476	17.258	17.380	37.431	34.132
	2.786		3.109		16.340		32.793	
	1.242		8.229		18.542		32.172	

Table C.8 Heavy metals concentration in stems of *V. zizanioides* in contaminated soil

Metal	Heavy metal concentration in stems of *V. zizanioides* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	0.000	1.638	3.703	3.475	8.039	9.227	10.664	10.527
	0.000		2.495		6.494		9.202	
	4.915		4.228		13.148		11.717	
Zn	22.383	35.000	45.287	55.870	62.779	56.036	70.729	54.929
	39.601		58.540		54.502		61.344	
	43.015		63.782		50.826		32.715	
Pb	5.958	6.385	7.406	9.152	8.838	10.781	8.542	13.708
	5.627		7.795		9.052		10.861	
	7.570		12.255		14.454		21.722	
Cu	2.880	2.230	2.606	2.629	5.441	4.226	18.025	21.204
	3.196		3.215		4.274		23.022	
	0.613		2.064		2.962		22.566	

Table C.9 Heavy metals concentration in leaves of *C. odorata* in contaminated soil

Metal	Heavy metal concentration in leaves of *C. odorata* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	11.249	11.427	13.069	12.871	14.159	12.513	15.543	14.346
	12.899		13.217		11.709		15.543	
	10.133		12.329		11.671		11.953	
Zn	94.550	98.735	87.932	87.393	88.188	95.646	78.843	72.006
	107.345		80.354		82.041		68.858	
	94.310		93.893		116.710		68.316	
Pb	13.092	15.324	10.487	11.311	12.136	13.369	11.775	11.911
	13.686		12.016		12.679		12.227	
	19.193		11.430		15.293		11.732	
Cu	5.486	5.007	3.722	4.584	3.109	3.324	19.395	18.933
	4.881		6.489		2.543		17.724	
	4.654		3.542		4.321		19.680	

Table C.10 Heavy metals concentration in leaves of *V. zizanioides* in contaminated soil

Metal	Heavy metal concentration in leaves of *V. zizanioides* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	5.659	5.089	7.343	8.181	4.218	5.067	30.605	25.938
	9.609		8.067		5.312		25.887	
	0.000		9.134		5.670		21.322	
Zn	38.840	43.712	44.468	49.155	26.714	26.533	71.680	63.775
	46.454		46.225		30.639		57.967	
	45.842		56.772		22.246		61.679	
Pb	9.954	9.774	3.687	3.942	2.767	3.216	1.757	1.555
	9.761		4.728		2.170		0.664	
	9.606		3.412		4.712		2.243	
Cu	11.062	9.283	7.833	13.692	8.803	7.329	5.272	3.857
	10.284		20.329		6.975		4.553	
	6.503		12.913		6.211		1.745	

1.4 Heavy metals concentration in the whole plants in contaminated soil

Table C.11 Heavy metals concentration in the whole of *C. odorata* in contaminated soil

Metal	Heavy metal concentration in the whole of *C. odorata* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	11.256	11.909	14.424	15.879	16.275	15.824	14.207	13.477
	12.378		15.433		15.804		13.458	
	12.092		17.781		15.395		12.766	
Zn	76.239	84.065	67.969	66.022	56.057	62.185	54.192	54.602
	92.953		58.827		54.477		51.393	
	83.002		71.269		76.019		58.220	
Pb	12.320	13.684	8.600	11.116	10.621	12.239	13.939	14.156
	13.189		12.360		12.471		15.573	
	15.543		12.389		13.625		12.956	
Cu	7.975	7.661	7.255	7.701	11.531	11.441	25.955	24.443
	8.537		7.370		10.235		23.655	
	6.471		8.479		12.557		23.721	

Table C.12 Heavy metals concentration in the whole of *V. zizanioides* in contaminated soil

Metal	Heavy metal concentration in the whole of *V. zizanioides* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	1.167	2.462	3.630	4.076	6.903	7.999	13.220	14.789
	1.657		3.207		6.459		16.470	
	4.562		5.392		10.636		14.676	
Zn	45.338	61.126	77.392	69.052	69.402	77.106	104.898	93.479
	56.974		60.263		65.100		111.047	
	81.067		69.500		96.815		64.493	
Pb	7.229	9.954	15.761	14.774	21.011	16.528	22.286	25.235
	7.999		14.906		9.916		29.242	
	14.633		13.655		18.657		24.178	
Cu	3.817	4.992	6.234	5.825	10.309	8.884	11.115	13.359
	4.816		6.734		7.025		19.904	
	6.342		4.506		9.317		9.057	

2. Heavy metals removal from synthetic soil by using *C. odorata* and *V. zizanioides*

2.1 Concentration of total heavy metals in synthetic soil

Table C.13 Concentration of total heavy metals in synthetic soil of *C. odorata* pot

Metal	Concentration of total heavy metals in synthetic soil (mg/kg)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	93.301	93.374	92.088	92.850	91.878	92.504	93.010	92.091
	94.390		92.370		92.512		91.135	
	92.432		94.091		93.122		92.128	
Zn	134.590	131.358	131.555	130.388	133.672	130.140	134.601	129.017
	134.696		127.366		126.870		125.308	
	124.788		132.243		129.878		127.144	
Pb	107.312	105.761	105.512	104.243	102.094	103.785	105.363	103.174
	106.515		105.082		103.312		100.098	
	103.455		102.133		105.948		104.060	
Cu	105.064	103.435	99.870	102.854	104.186	102.116	103.239	101.723
	101.870		103.509		100.879		97.153	
	103.370		105.183		101.284		104.776	

Table C.14 Concentration of total heavy metals in synthetic soil of *V. zizanioides* pot

Metal	Concentration of total heavy metal in synthetic soil (mg/kg)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	95.898	93.964	89.734	93.483	89.758	92.709	93.620	92.030
	89.864		95.083		93.123		89.706	
	96.128		95.630		95.247		92.764	
Zn	131.052	126.118	138.258	125.556	121.027	125.304	120.521	124.803
	115.028		110.255		132.127		127.216	
	132.275		128.155		122.757		126.673	
Pb	108.631	107.825	108.578	106.275	103.750	105.399	102.827	104.371
	108.575		105.494		107.607		104.525	
	106.270		104.753		104.840		105.760	
Cu	106.656	106.642	106.615	105.876	106.858	104.828	104.205	103.643
	109.662		105.158		104.909		104.824	
	103.608		105.855		102.716		101.901	

2.2 Phytoavailability of heavy metals in synthetic soil by DTPA extraction method

Table C.15 Phytoavailability of heavy metals in synthetic soil of *C. odorata* pot

Metal	Phytoavailability of heavy metals in synthetic soil (mg/kg)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	65.739	87.738	73.450	78.196	66.235	78.036	53.505	65.912
	118.235		68.813		71.784		67.900	
	79.239		92.324		96.090		76.332	
Zn	56.493	72.090	59.163	62.636	52.198	62.523	44.080	55.037
	94.310		55.877		55.831		61.237	
	65.467		72.867		79.540		59.792	
Pb	54.342	42.969	29.739	31.781	15.953	30.753	20.221	23.593
	40.262		20.291		21.288		21.555	
	34.302		45.314		55.017		29.004	
Cu	63.655	74.655	59.696	73.902	58.732	69.261	47.303	57.154
	61.279		96.708		67.901		51.417	
	99.030		65.300		81.149		72.741	

Table C.16 Phytoavailability of heavy metals in synthetic soil of *V. zizanioides* pot

Metal	Phytoavailability of heavy metals in synthetic soil (mg/kg)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	58.644	83.938	94.816	76.317	45.624	68.831	77.912	65.640
	45.409		67.694		79.808		56.366	
	147.761		66.439		81.062		62.641	
Zn	45.270	73.580	77.108	60.049	35.832	55.309	59.789	49.237
	38.698		50.936		66.531		45.741	
	136.773		52.104		63.565		42.180	
Pb	93.429	69.414	42.700	52.525	22.746	38.721	50.488	37.993
	42.960		103.430		46.846		42.720	
	71.854		11.446		46.571		20.770	
Cu	106.776	72.887	57.672	60.559	69.243	57.850	40.023	57.769
	56.043		40.125		49.337		67.536	
	55.843		83.879		54.971		65.747	

2.3 Heavy metals concentration in various parts of plant in synthetic soil

Table C.17 Heavy metals concentration in roots of *C. odorata* in synthetic soil

Metal	Heavy metals accumulation in roots of *C. odorata* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	142.111	135.497	114.663	117.041	315.327	326.630	141.566	165.422
	139.444		93.649		329.816		157.925	
	124.936		142.811		334.749		196.775	
Zn	97.440	98.235	90.862	93.201	168.970	162.434	117.238	108.836
	97.111		89.996		163.206		100.490	
	100.154		98.744		155.127		108.780	
Pb	21.369	22.373	88.987	98.497	32.001	35.376	43.559	41.246
	21.713		107.386		36.889		41.912	
	24.036		99.118		37.237		38.267	
Cu	34.920	27.618	42.842	37.384	96.524	90.168	53.753	52.426
	21.408		28.222		78.455		47.386	
	26.527		41.089		95.526		56.138	

Table C.18 Heavy metals concentration in roots of *V. zizanioides* in synthetic soil

Metal	Heavy metals concentration in roots of *V. zizanioides* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	136.446	159.280	146.481	170.036	294.635	313.018	303.068	337.011
	160.603		170.032		346.224		349.203	
	180.792		193.596		298.196		358.762	
Zn	271.257	249.591	208.883	255.837	413.746	375.595	310.899	287.841
	255.754		282.075		402.106		302.869	
	221.762		276.553		310.933		249.754	
Pb	169.568	138.206	235.268	186.505	130.125	144.920	193.825	232.023
	119.674		126.251		151.435		211.489	
	125.376		197.996		153.202		290.755	
Cu	79.132	103.057	79.132	103.057	299.033	295.862	216.092	250.596
	126.855		126.855		280.937		286.929	
	103.185		103.185		307.615		248.768	

Table C.19 Heavy metals concentration in stems of *C. odorata* in synthetic soil

Metal	Heavy metals concentration in stems of *C. odorata* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	123.386	126.527	97.138	86.466	122.983	106.183	70.994	101.359
	131.681		80.959		99.283		114.043	
	124.514		81.301		96.284		119.038	
Zn	88.552	103.612	76.888	68.150	97.858	81.569	89.827	91.024
	102.634		66.023		82.418		97.804	
	119.650		61.540		64.431		85.441	
Pb	3.806	3.323	7.934	7.843	27.789	25.732	13.153	11.076
	3.339		7.631		22.657		10.519	
	2.823		7.963		26.751		9.558	
Cu	11.114	8.742	17.125	17.102	43.444	43.806	26.953	27.052
	7.659		17.933		54.899		26.204	
	7.453		16.248		33.074		27.998	

Table C.20 Heavy metals concentration in stems of *V. zizanioides* in synthetic soil

Metal	Heavy metal accumulation in stems of *V. zizanioides* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	199.842	216.578	110.079	140.322	184.396	172.220	178.637	188.492
	209.536		138.743		180.977		214.673	
	240.356		172.144		151.288		172.166	
Zn	119.707	115.163	147.032	135.603	188.406	172.536	316.027	250.982
	119.451		113.676		168.796		232.375	
	106.330		146.101		160.407		204.545	
Pb	28.217	23.841	42.358	38.837	20.978	34.804	65.295	111.423
	20.579		7.641		68.643		145.829	
	22.727		66.510		14.791		123.145	
Cu	99.921	95.478	31.109	54.227	75.758	65.618	86.433	62.968
	88.095		89.602		60.846		43.722	
	98.417		41.970		60.250		58.751	

Table C.21 Heavy metals concentration in leaves of *C. odorata* in synthetic soil

Metal	Heavy metals concentration in leaves of *C. odorata* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	57.681	69.264	127.051	112.070	151.824	149.876	95.118	90.008
	63.899		94.648		140.941		93.125	
	86.212		114.513		156.863		81.781	
Zn	231.859	228.238	136.831	141.646	164.042	198.820	182.418	164.720
	237.170		138.664		218.661		177.428	
	215.686		149.444		213.758		134.313	
Pb	9.298	10.996	18.865	18.314	32.887	33.781	19.110	21.831
	12.650		18.156		31.201		23.827	
	11.039		17.920		37.255		22.555	
Cu	9.903	8.421	13.287	12.615	13.287	12.615	15.288	13.469
	8.677		10.657		10.657		11.004	
	6.684		13.902		13.902		14.115	

Table C.22 Heavy metals concentration in leaves of *V. zizanioides* in synthetic soil

Metal	Heavy metals concentration in leaves of *V. zizanioides* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	48.515	57.557	141.614	126.758	128.832	141.687	245.419	220.313
	57.174		127.796		154.522		201.288	
	66.980		110.865		141.706		214.232	
Zn	27.257	69.335	185.127	187.174	186.896	199.233	278.141	300.165
	92.872		214.058		236.745		351.583	
	87.877		162.338		174.057		270.771	
Pb	89.399	83.302	83.998	54.666	49.084	46.673	61.520	69.605
	63.898		42.529		53.677		77.200	
	96.611		37.472		37.258		70.094	
Cu	17.430	51.481	74.842	78.220	61.846	59.652	65.261	78.919
	80.805		75.879		60.386		78.361	
	56.208		83.940		56.725		93.136	

2.4 Heavy metals accumulation in all parts of plant in synthetic soil

Table C.23 Heavy metals concentration in the whole of *C. odorata* in synthetic soil

Metal	Heavy metal concentration in the whole of *C. odorata* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	94.587	98.494	114.935	102.046	176.308	156.044	94.517	107.414
	91.511		90.499		139.228		117.981	
	109.383		100.703		152.595		109.743	
Zn	160.902	165.777	105.050	106.185	152.904	149.221	118.275	118.695
	182.866		106.322		153.661		111.630	
	153.562		107.183		141.098		126.181	
Pb	9.882	10.149	40.926	31.468	31.799	30.797	21.011	21.692
	9.845		36.394		27.934		22.450	
	10.719		17.085		32.657		21.616	
Cu	15.083	11.787	24.765	19.296	33.904	34.185	25.199	25.354
	8.967		16.918		36.158		26.460	
	11.311		16.204		32.493		24.404	

Table C.24 Heavy metals concentration in the whole of *V. zizanioides* in synthetic soil

Metal	Heavy metal concentration in the whole of *V. zizanioides* (mg/kg dry weight)							
	30 day	AVG	60 day	AVG	90 day	AVG	120 day	AVG
Cd	161.593	160.198	124.638	149.703	200.177	236.512	230.642	261.947
	122.245		164.647		338.540		377.300	
	196.756		159.824		170.819		177.900	
Zn	149.616	156.748	169.323	195.688	253.502	285.948	306.383	311.324
	119.797		216.757		417.686		486.358	
	200.831		200.983		186.657		141.233	
Pb	74.489	77.360	108.796	107.080	76.452	125.211	142.741	193.922
	47.517		81.693		207.555		298.212	
	110.074		130.751		91.627		140.813	
Cu	82.310	90.148	50.652	81.268	145.853	153.418	121.248	142.262
	79.420		112.567		190.227		194.629	
	108.713		80.583		124.173		110.910	

3. Dry weight of plants

Table C.25 Dry weight of *C. odorata* and *V. zizanioides* in contaminated and synthetic soil

Time (day)	Soil	*C.odorata* (g)	AVG	*V. zizaniodies* (g)	AVG
30	Control	1.88	2.21	3.73	4.50
		2.43		4.40	
		2.31		5.36	
	Contaminated	2.88	1.92	4.87	3.09
		1.71		2.52	
		1.17		1.88	
	Synthetic	2.39	2.04	3.92	4.06
		2.09		1.99	
		1.65		6.26	
60	Control	4.40	4.17	4.57	5.54
		4.70		6.08	
		3.40		5.96	
	Contaminated	2.60	3.70	5.00	3.93
		6.40		2.80	
		2.10		4.00	
	Synthetic	3.10	3.93	3.80	5.13
		2.10		7.80	
		6.60		3.80	
90	Control	6.80	6.67	7.50	7.93
		7.30		5.30	
		5.90		11.00	
	Contaminated	6.00	6.13	5.19	4.68
		6.50		5.27	
		5.90		3.59	
	Synthetic	3.30	3.83	5.71	7.97
		3.40		6.80	
		4.80		11.41	
120	Control	12.20	12.73	13.69	13.87
		12.60		17.44	
		13.40		10.48	
	Contaminated	8.40	10.23	6.40	6.27
		8.80		7.50	
		13.50		4.90	
	Synthetic	7.60	10.13	8.90	10.47
		15.20		7.40	
		7.60		15.10	

APPENDIX D

STATISTIC ANALYSIS

1. Heavy metals removal from contaminated soil by using *C. odorata* and *V. zizanioides*

1.1 Concentration of total heavy metals in contaminated soil

Table D.1 Concentration of total heavy metals in contaminated soil of *C. odorata* pot

Cd

Duncan

Time	N	Subset for alpha = .05	
		1	2
120 day	3	38.01600	
90 day	3	38.70833	
60 day	3	41.25733	
30 day	3		46.01500
Sig.		.091	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05	
		1	2
120 day	3	1776.80400	
90 day	3		1990.27333
60 day	3		2010.65633
30 day	3		2014.23800
Sig.		1.000	.563

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05	
		1	2
120 day	3	75.90133	
90 day	3	79.75767	
60 day	3		84.94133
30 day	3		86.62867
Sig.		.112	.457

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	21.89367
90 day	3	22.08900
60 day	3	22.44533
30 day	3	23.19000
Sig.		.064

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.2 Concentration of total heavy metals in contaminated soil of *V. zizanioides* pot

Cd

Duncan

Time	N	Subset for alpha = .05	
		1	2
120 day	3	37.42500	
90 day	3	39.81333	39.81333
60 day	3	40.92467	40.92467
30 day	3		42.04633
Sig.		.072	.223

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05	
		1	2
120 day	3	1808.18933	
90 day	3		1986.57933
60 day	3		2009.29600
30 day	3		2045.25467
Sig.		1.000	.258

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	75.42433
90 day	3	76.82167
60 day	3	77.31733
30 day	3	81.00767
Sig.		.077

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	21.90867
90 day	3	22.08233
60 day	3	22.39767
30 day	3	22.47500
Sig.		.628

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

1.2 Phytoavailability of heavy metals in contaminated soil by DTPA extraction method

Table D.3 Phytoavailability of heavy metals in contaminated soil of *C. odorata* pot

Cd

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	4.6943
90 day	3	4.9147
60 day	3	4.9283
30 day	3	5.4313
Sig.		.322

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	201.3303
90 day	3	204.5593
60 day	3	218.4807
30 day	3	218.8333
Sig.		.559

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05	
		1	2
120 day	3	5.77300	
90 day	3	6.43000	6.43000
60 day	3	6.48933	6.48933
30 day	3		6.96967
Sig.		.095	.192

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	2.03233
90 day	3	2.05200
60 day	3	2.09467
30 day	3	2.18833
Sig.		.099

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.4 Phytoavailability of heavy metals in contaminated soil of *V. zizanioides* pot

Cd

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	3.86933
90 day	3	4.65500
60 day	3	5.22000
30 day	3	5.51533
Sig.		.073

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	174.05100
90 day	3	201.28233
60 day	3	219.52433
30 day	3	221.24500
Sig.		.124

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	5.83333
90 day	3	6.27667
60 day	3	6.48800
30 day	3	6.81467
Sig.		.166

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	2.03867
90 day	3	2.04233
60 day	3	2.06767
30 day	3	2.08067
Sig.		.635

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

1.3 Heavy metals concentration in various parts of plant in contaminated soil

Table D.5 Heavy metals concentration in roots of *C. odorata* in contaminated soil

Cd

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	15.70300		
120 day	3	16.05300		
60 day	3		36.73800	
90 day	3			50.21800
Sig.		.943	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05	
		1	2
90 day	3	66.69600	
120 day	3	88.22933	
60 day	3	98.52000	98.52000
30 day	3		123.44467
Sig.		.053	.101

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05
		1
30 day	3	11.37900
90 day	3	20.37967
120 day	3	23.76933
60 day	3	29.07433
Sig.		.059

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05			
		1	2	3	4
120 day	3	9.40767			
90 day	3		18.64800		
60 day	3			25.43367	
30 day	3				31.88867
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.6 Heavy metals concentration in roots of *V. zizanioides* in contaminated soil

Cd

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	3.23833		
60 day	3	3.61800	3.61800	
90 day	3		7.01800	
120 day	3			11.24300
Sig.		.808	.055	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05	
		1	2
60 day	3	85.40600	
30 day	3	111.05300	
90 day	3	126.61500	126.61500
120 day	3		163.18000
Sig.		.078	.099

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	16.32067	
60 day	3	23.99600	
90 day	3	26.50700	
120 day	3		40.63000
Sig.		.126	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	5.66767	
60 day	3	7.13767	
120 day	3	12.33467	12.33467
90 day	3		15.61733
Sig.		.087	.346

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.7 Heavy metals concentration in stems of *C. odorata* in contaminated soil

Cd

Duncan

Time	N	Subset for alpha = .05
		1
90 day	3	8.93267
30 day	3	11.16133
120 day	3	12.00733
60 day	3	13.07100
Sig.		.069

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
120 day	3	18.76767		
90 day	3	26.80767	26.80767	
60 day	3		29.86667	
30 day	3			45.27833
Sig.		.063	.435	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
60 day	3	4.83867		
90 day	3		8.59867	
30 day	3			12.01900
120 day	3			12.12867
Sig.		1.000	1.000	.935

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05			
		1	2	3	4
30 day	3	1.79433			
60 day	3		6.47633		
90 day	3			17.38000	
120 day	3				34.13200
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.8 Heavy metals concentration in stems of *V. zizanioides* in contaminated soil

Cd

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	1.63833	
60 day	3	3.47533	
90 day	3		9.22700
120 day	3		10.52767
Sig.		.371	.521

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05
		1
30 day	3	34.99967
120 day	3	54.92933
60 day	3	55.86967
90 day	3	56.03567
Sig.		.093

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05
		1
30 day	3	6.38500
60 day	3	9.15200
90 day	3	10.78133
120 day	3	13.70833
Sig.		.075

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	2.22967	
60 day	3	2.62833	
90 day	3	4.22567	
120 day	3		21.20433
Sig.		.204	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.9 Heavy metals concentration in leaves of *C. odorata* in contaminated soil

Cd

Duncan

Time	N	Subset for alpha = .05
		1
30 day	3	11.42700
90 day	3	12.51300
60 day	3	12.87167
120 day	3	14.34633
Sig.		.050

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05
		1
60 day	3	87.39300
120 day	3	87.39300
90 day	3	95.64633
30 day	3	98.73500
Sig.		.271

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05	
		1	2
60 day	3	11.31100	
120 day	3	11.91133	11.91133
90 day	3	13.36933	13.36933
30 day	3		15.32367
Sig.		.245	.071

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05	
		1	2
90 day	3	3.32433	
60 day	3	4.58433	
30 day	3	5.00700	
120 day	3		18.93300
Sig.		.110	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.10 Heavy metals concentration in leaves of *V. zizanioides* in contaminated soil

Cd

Duncan

Time	N	Subset for alpha = .05	
		1	2
90 day	3	5.06667	
30 day	3	5.08933	
60 day	3	8.18133	
120 day	3		25.93800
Sig.		.313	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
90 day	3	26.53300		
30 day	3		43.71200	
60 day	3		49.15500	
120 day	3			63.77533
Sig.		1.000	.276	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05	
		1	2
90 day	3	5.06667	
30 day	3	5.08933	
60 day	3	8.18133	
120 day	3		25.93800
Sig.		.313	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05	
		1	2
120 day	3	3.85667	
90 day	3	7.32967	7.32967
30 day	3	9.28300	9.28300
60 day	3		13.69167
Sig.		.111	.069

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000

1.4 Heavy metals concentration in the whole plants in contaminated soil

Table D.11 Heavy metals concentration in the whole of *C. odorata* in contaminated soil

Cd

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	11.90867	
120 day	3	13.47700	
90 day	3		15.82467
60 day	3		15.87933
Sig.		.092	.948

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05	
		1	2
120 day	3	54.60167	
90 day	3	62.18433	
60 day	3	66.02167	
30 day	3		84.06467
Sig.		.140	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05
		1
60 day	3	11.11633
90 day	3	12.23900
30 day	3	13.68400
120 day	3	14.15600
Sig.		.074

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	7.66100		
60 day	3	7.70133		
90 day	3		11.44100	
120 day	3			24.44367
Sig.		.965	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.12 Heavy metals concentration in the whole of *V. zizanioides* contaminated soil

Cd

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	2.46200		
60 day	3	4.07633		
90 day	3		7.99933	
120 day	3			14.78867
Sig.		.298	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05
		1
30 day	3	61.12633
60 day	3	69.05167
90 day	3	77.10567
120 day	3	93.47933
Sig.		.077

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	9.95367	
60 day	3	14.77400	
90 day	3	16.52800	
120 day	3		25.23533
Sig.		.091	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	4.99167	
60 day	3	5.82467	
90 day	3	8.88367	8.88367
120 day	3		13.35867
Sig.		.181	.117

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

2. Heavy metals removal from synthetic soil by using *C. odorata* and *V. zizanioides*

2.1 Concentration of total heavy metals in synthetic soil

Table D.13 Concentration of total heavy metals in synthetic soil of *C. odorata*

Cd

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	85.73900
90 day	3	88.81633
60 day	3	88.85133
30 day	3	89.35500
Sig.		.287

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	89.01667
90 day	3	90.12633
60 day	3	90.33733
30 day	3	91.35800
Sig.		.755

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	89.91300
90 day	3	91.76567
60 day	3	93.23733
30 day	3	95.77700
Sig.		.213

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	89.42833
90 day	3	89.86700
60 day	3	92.15467
30 day	3	95.43800
Sig.		.332

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.14 Concentration of total heavy metals in synthetic soil of *V. zizanioides*

Cd

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	82.03000
90 day	3	83.27000
60 day	3	87.07867
30 day	3	89.96933
Sig.		.093

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	90.88600
90 day	3	95.49400
60 day	3	95.55067
30 day	3	96.11900
Sig.		.359

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05	
		1	2
120 day	3	87.36167	
90 day	3	90.38700	
60 day	3	94.27767	94.27767
30 day	3		97.95467
Sig.		.051	.238

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	89.62000
90 day	3	91.85200
60 day	3	94.88833
30 day	3	97.62300
Sig.		.058

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

2.2 Phytoavailability of heavy metals in synthetic soil by DTPA extraction method

Table D.15 Phytoavailability of heavy metals in synthetic soil of *C. odorata* pot

Cd

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	65.9123
90 day	3	78.0363
60 day	3	78.1957
30 day	3	87.7377
Sig.		.198

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	55.0363
90 day	3	62.5230
60 day	3	62.6357
30 day	3	72.0900
Sig.		.198

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000

Pb

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	23.59333
90 day	3	30.75267
60 day	3	31.78133
30 day	3	42.96867
Sig.		.139

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	57.15367
90 day	3	69.26067
60 day	3	73.90133
30 day	3	74.65467
Sig.		.270

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.16 Phytoavailability of heavy metals in synthetic soil of *V. zizanioides* pot

Cd

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	65.63967
90 day	3	68.83133
60 day	3	76.31633
30 day	3	83.93800
Sig.		.516

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	49.23667
90 day	3	55.30933
60 day	3	60.04933
30 day	3	73.58033
Sig.		.376

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	37.99267
90 day	3	38.72100
60 day	3	52.52533
30 day	3	69.41433
Sig.		.240

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05
		1
120 day	3	57.76867
90 day	3	57.85033
60 day	3	60.55867
30 day	3	72.88733
Sig.		.420

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

2.3 Heavy metals concentration in various parts of plant in synthetic soil

Table D.17 Heavy metals concentration in roots of *C. odorata* in synthetic soil

Cd

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
60 day	3	117.0410		
30 day	3	135.4970	135.4970	
120 day	3		165.4220	
90 day	3			326.6306
Sig.		.291	.104	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
60 day	3	93.20067		
30 day	3	98.23500	98.23500	
120 day	3		108.8360	
90 day	3			162.4343
Sig.		.335	.063	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	22.37267		
90 day	3		35.37567	
120 day	3		41.24600	
60 day	3			98.49700
Sig.		1.000	.194	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	27.61833		
60 day	3	37.38433		
120 day	3		52.42567	
90 day	3			90.16833
Sig.		.156	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.18 Heavy metals concentration in roots of *V. zizanioides* in synthetic soil

Cd

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	159.2803	
60 day	3	170.0363	
90 day	3		313.0183
120 day	3		337.0110
Sig.		.630	.296

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	249.5910	
60 day	3	255.8370	
120 day	3	287.8406	
90 day	3		375.5950
Sig.		.300	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	138.2060	
90 day	3	144.9206	
60 day	3	186.5050	186.5050
120 day	3		232.0230
Sig.		.201	.209

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	103.0573	
60 day	3	103.0573	
120 day	3		250.5963
90 day	3		295.8616
Sig.		1.000	.061

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.19 Heavy metals concentration in stems of *C. odorata* in synthetic soil

Cd

Duncan

Time	N	Subset for alpha = .05	
		1	2
60 day	3	86.46600	
120 day	3	101.3583	101.3583
90 day	3	106.1833	106.1833
30 day	3		126.5270
Sig.		.184	.101

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05	
		1	2
60 day	3	68.15033	
90 day	3	81.56900	81.56900
120 day	3	91.02400	91.02400
30 day	3		103.6120
Sig.		.064	.072

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05			
		1	2	3	4
30 day	3	3.32267			
60 day	3		7.84267		
120 day	3			11.07667	
90 day	3				25.73233
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	8.74200		
60 day	3	17.10200	17.10200	
120 day	3		27.05167	
90 day	3			43.80567
Sig.		.104	.061	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.20 Heavy metals concentration in stems of *V. zizanioides* in synthetic soil

Cd

Duncan

Time	N	Subset for alpha = .05	
		1	2
60 day	3	140.3220	
90 day	3	172.2203	172.2203
120 day	3		188.4920
30 day	3		216.5780
Sig.		.140	.060

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	115.1626	
60 day	3	135.6030	
90 day	3	172.5363	
120 day	3		250.9823
Sig.		.065	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	23.84100	
90 day	3	34.80400	
60 day	3	38.83633	
120 day	3		111.4230
Sig.		.567	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05	
		1	2
60 day	3	54.22700	
120 day	3	62.96867	62.96867
90 day	3	65.61800	65.61800
30 day	3		95.47767
Sig.		.516	.089

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.21 Heavy metals concentration in leaves of *C. odorata* in synthetic soil

Cd

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	69.26400		
120 day	3	90.00800	90.00800	
60 day	3		112.0706	
90 day	3			149.8760
Sig.		.074	.060	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05	
		1	2
60 day	3	141.6463	
120 day	3	141.6463	
90 day	3		198.8203
30 day	3		228.2383
Sig.		1.000	.065

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	10.99567		
60 day	3		18.31367	
120 day	3		21.83067	
90 day	3			33.78100
Sig.		1.000	.082	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	8.42133	
60 day	3		12.61533
90 day	3		12.61533
120 day	3		13.46900
Sig.		1.000	.600

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.22 Heavy metals concentration in leaves of *V. zizanioides* in synthetic soil

Cd

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	57.55633		
60 day	3		126.7583	
90 day	3		141.6866	
120 day	3			220.3130
Sig.		1.000	.281	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	69.33533		
60 day	3		187.1743	
90 day	3		199.2326	
120 day	3			300.1650
Sig.		1.000	.690	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05		
		1	2	3
30 day	3	57.55633		
60 day	3		126.7583	
90 day	3		141.6866	
120 day	3			220.3130
Sig.		1.000	.281	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05	
		1	2
120 day	3	3.85667	
60 day	3	13.69167	
30 day	3		51.48100
90 day	3		59.65233
Sig.		.483	.558

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

2.4 Heavy metals concentration in the whole plants in synthetic soil

Table D.23 Heavy metals concentration in the whole plants of *C. odorata* in synthetic soil

Cd

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	98.49367	
60 day	3	102.0456	
120 day	3	107.4136	
90 day	3		156.0436
Sig.		.462	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05	
		1	2
60 day	3	106.1850	
120 day	3	118.6953	
90 day	3		149.2210
30 day	3		165.7766
Sig.		.133	.058

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05	
		1	2
30 day	3	10.14867	
120 day	3	21.69233	21.69233
90 day	3		30.79667
60 day	3		31.46833
Sig.		.060	.114

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05			
		1	2	3	4
30 day	3	11.78700			
60 day	3		19.29567		
120 day	3			25.35433	
90 day	3				34.18500
Sig.		1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Table D.24 Heavy metals concentration in the whole plants of *V. zizanioides* synthetic soil

Cd

Duncan

Time	N	Subset for alpha = .05
		1
60 day	3	149.70300
30 day	3	160.19800
90 day	3	236.51200
120 day	3	261.94733
Sig.		.109

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Zn

Duncan

Time	N	Subset for alpha = .05
		1
30 day	3	156.74800
60 day	3	195.68767
90 day	3	285.94833
120 day	3	311.32467
Sig.		.136

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Pb

Duncan

Time	N	Subset for alpha = .05
		1
30 day	3	77.36000
60 day	3	107.08000
90 day	3	125.21133
120 day	3	193.92200
Sig.		.059

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

Cu

Duncan

Time	N	Subset for alpha = .05	
		1	2
60 day	3	81.26733	
30 day	3	90.14767	90.14767
120 day	3	142.2623	142.2623
90 day	3		153.4176
Sig.		.064	.056

Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 3.000.

APPENDIX E

1. Soil map from Tak Province

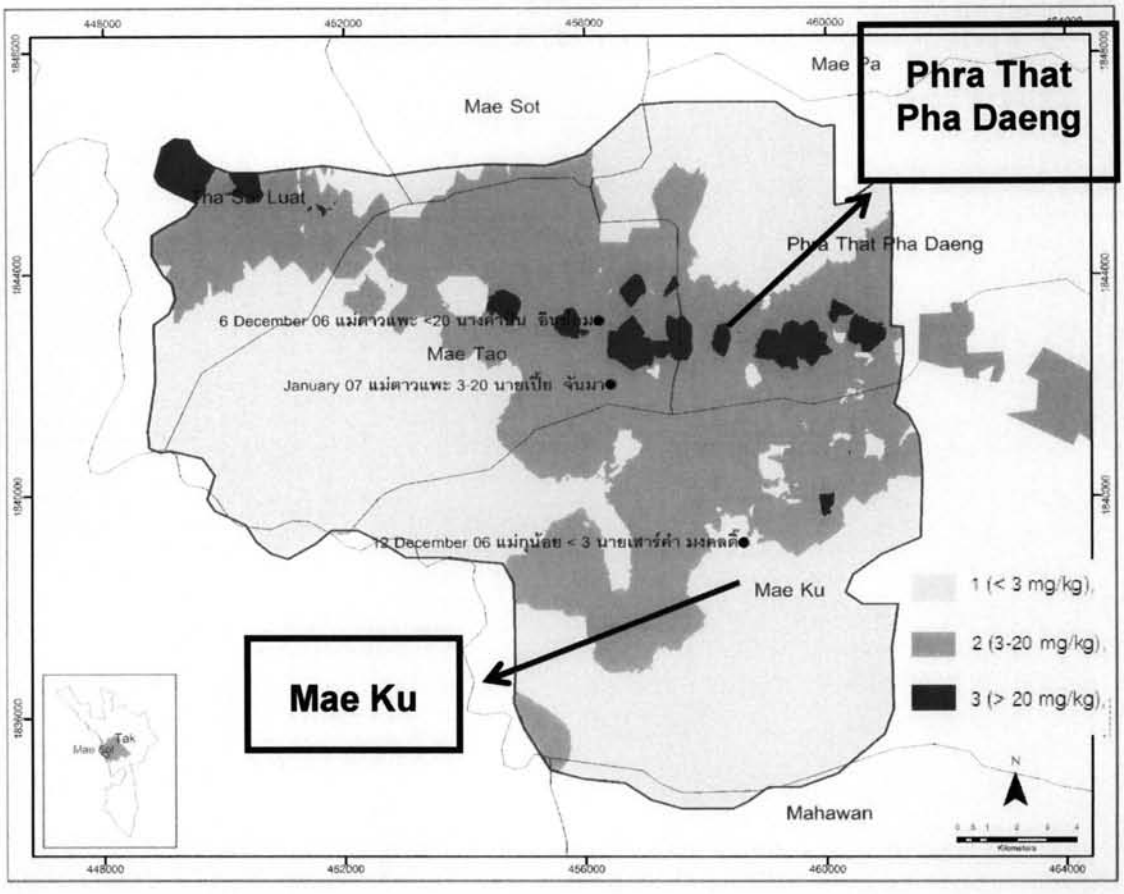


Figure E.1 The map for site selection and sampling point in experiment in Mae Ku (uncontaminated soil) and in Phra That Pha Daeng sub-district (contaminated soil) of Mae Sot district, Tak province.

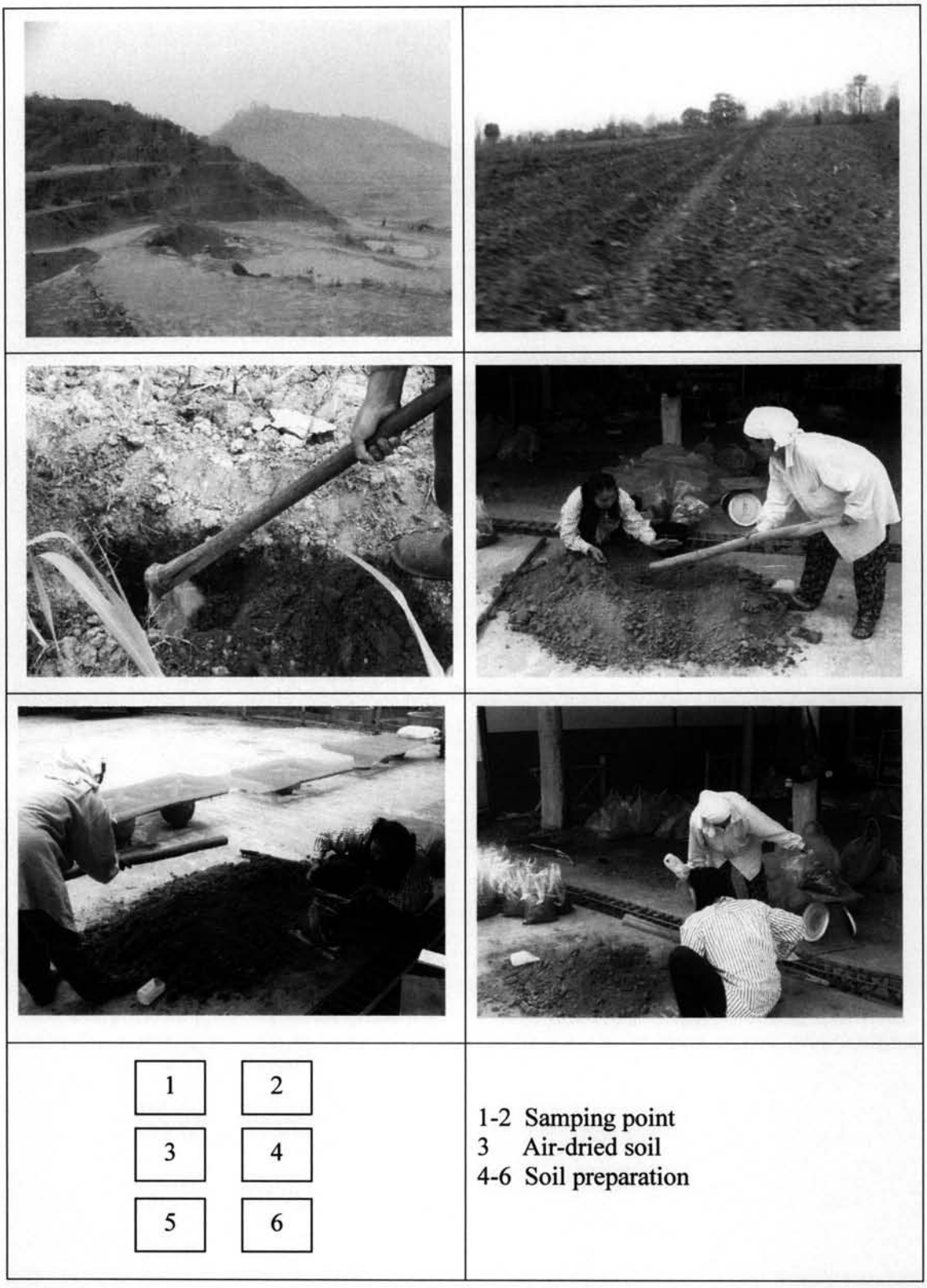


Figure E.2 Soil collection and preparation from Mae Sot district, Tak province

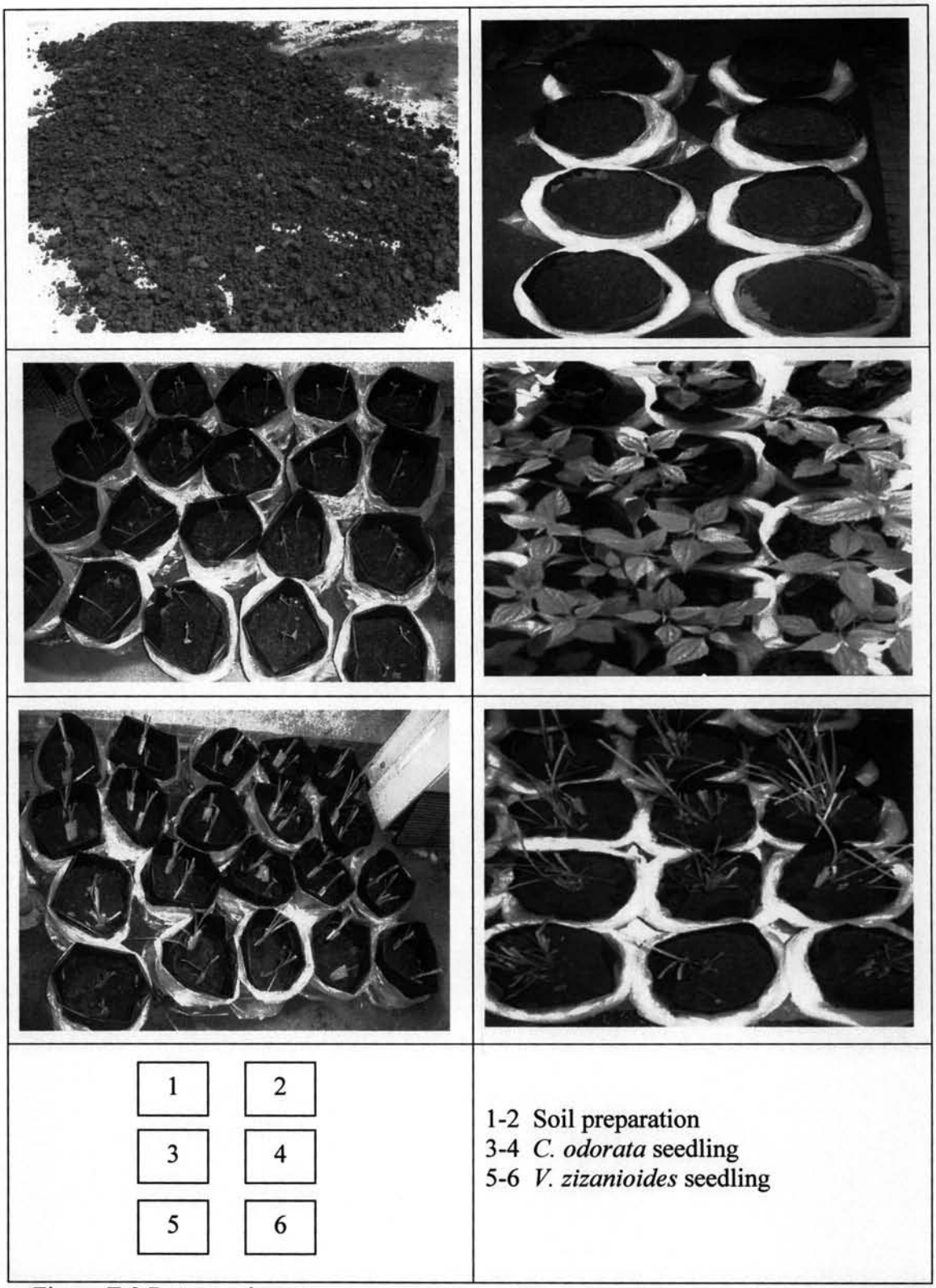
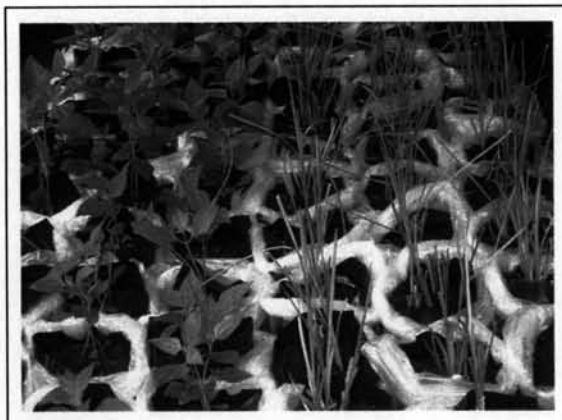
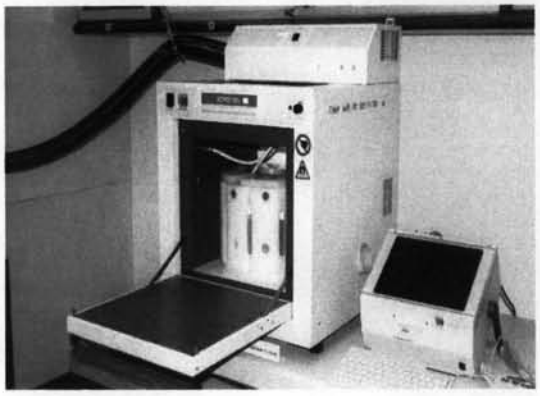
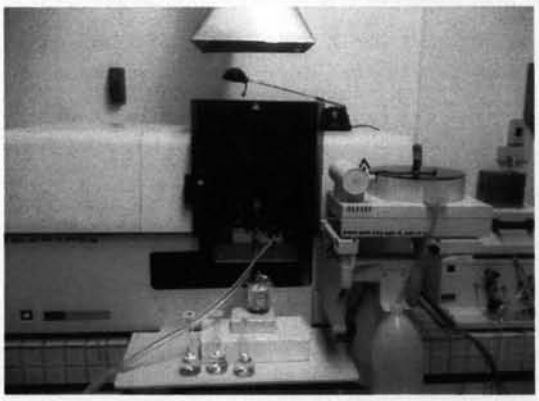


Figure E.3 Pot experiment

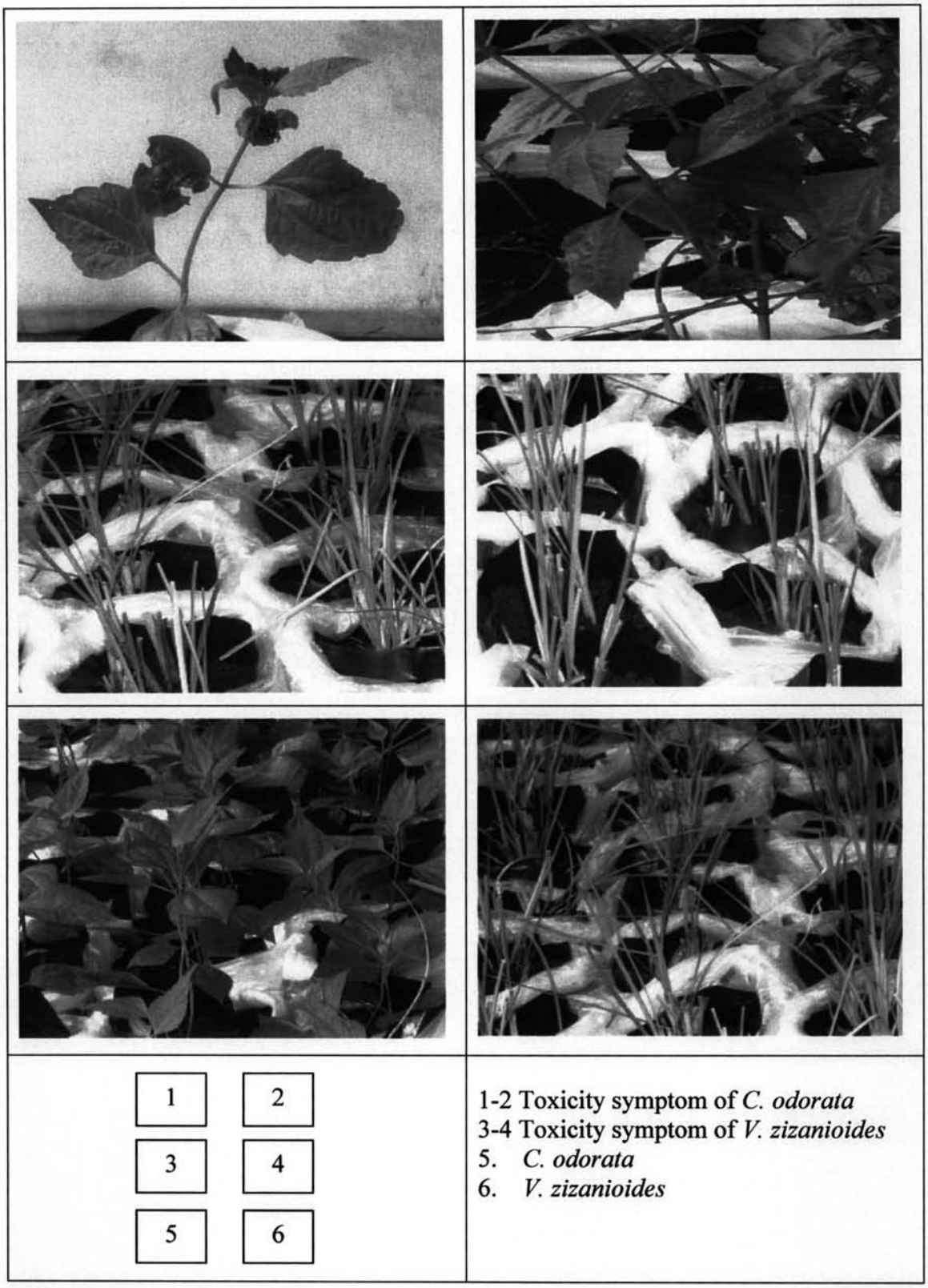






1	1. Plants collection
2	2. Oven
3	3. Plant dry weight
4	4. Microwave
5	5. Solution samples
6	6. Atomic Absorption Spectroscopy

Figure E.4 Samples analysis



1 2 3 4 5 6	1-2 Toxicity symptom of *C. odorata* 3-4 Toxicity symptom of *V. zizanioides* 5. *C. odorata* 6. *V. zizanioides*

Figure E.5 Phytotoxicity of plants

BIOGRAPHY

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1. Wilaiwan Chaengcharoen, Chantra Tongcumpou and Pantawat Sampanpanish. *Cd, Zn, Pb and Cu removal from contaminated soil with Chromolaena ordorata (Siam weed).* 7th National Environmental Conference, Bangkok, Thailand, March 12th - 14th , 2008 organized by The Environmental Engineering Association of Thailand.
2. Wilaiwan Chaengcharoen, Chantra Tongcumpou and Pantawat Sampanpanish. *Comparision of heavy metals removal from contaminated soil by Siam weed (Chromolaena odorata) and Vetiver grass (Vetiveria zizanioides).* 1st The Proceedings of Pure and Applied Chemistry International Conference (PACCON) 2008, Bangkok, Thailand, January 30th - February 1st, 2008 organized by Kasetsart University, Chemical Society of Thailand, and The Thailand Research Fund.
3. Wilaiwan Chaengcharoen, Chantra Tongcumpou and Pantawat Sampanpanish. *Removal of heavy metal from contaminated soil by Siam weed and Vetiver grass under protected cultivation.* 12th Biological Sciences Graduate Congress (BSGC), Kuala Lumpur, Malaysia, December 17th - 19th, 2007 organized by Bendahari University Malaya.