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DECISION SUPPORT FOR THE MANAGEMENT OF AGROSYSTEMS CONTAMINATED WITH METALS: RESEARCH PROGRAM AND PRELIMINARY RESULTS

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Abstract:
In this paper we present a project and its preliminary results after one year of research. The project aims to implement in Romania the research directions recently identified at European level within the concerted action AROMIS (Assessment and Reduction of heavy metal input into agro-ecosystems). The objectives of the project are: 1) the assessment of the balance of metals at national and regional scale, 2) the optimization of the farm integrated management in function of the metals concentration in soil and plants, and 3) The creation of an alert system at national level. The final products of the Project should be: 1) an expert system for the farm level concerning the optimization of the technological elements in the presence of heavy metals, experimented and validated, 2) an alert system at national level concerning the changing in the risk as a result of the variation of human and natural large scale control parameters of metals mobility, experimented and checked. Final results which will open new perspectives of applied research should be 3) Optimization pathways for the soil monitoring system and modalities for its coupling with other monitoring systems in order to supply coherent data sets to an integrated information system. The preliminary results reported here are spatially referenced data of metals distribution in agricultural soils around Copşa Mică.

Keywords: heavy metals, agrosystems, decision support

In 2002-2003 Romania was involved in the European concerted action AROMIS, dealing with the distribution of toxic metals in agricultural soils. The purpose of this project was to build a data-base at European level and to assess based on it metal balances both at representative farm level and national level. For most of the countries (including Romania) it was possible to build only rough balances because of data absence and / or quality (table 1, Iordache and Dumitru, in preparation). In this context we launched in 2008 a national project having as main goal to implement the research directions identified in 2002-2003, leading to the computation of farm gate and national level balances of metals. Figure 1 presents the Pert diagram of this project (Balance of metals in Romanian agrosystems – METAGRO).

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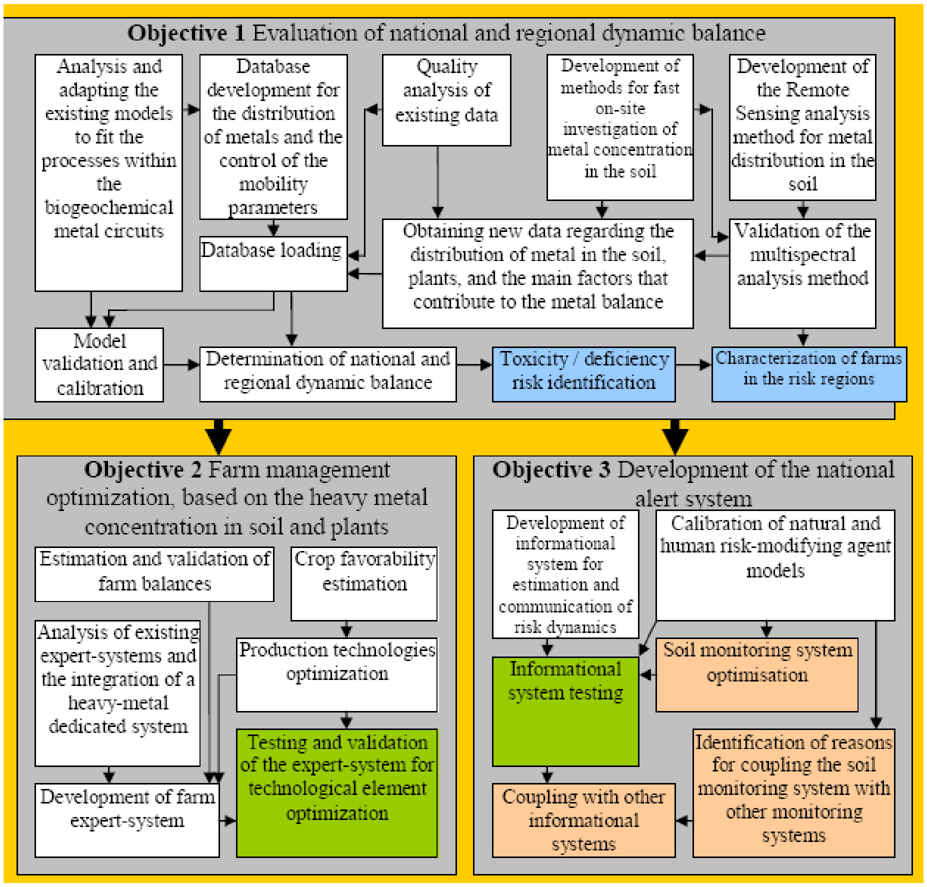
Table 1 Estimated fluxes and balance for agricultural lands of Romania (g/ha agricultural area in year 2000), the land surface relevant for the considered fluxes, and a short characterization of the data used for computation (Romania country report, Iordache and Dumitru, in preparation)..

Inputs (as over 14856800 ha)	Cu	Zn	Co	Ni	Mn	Cd	Pb	Cr	Real surface of input / output (ha)	Source of data: concentrations, amount or fluxes
Urban sewage sludge	0.596	2.386	0.030	0.067	0.540	0.046	0.431	1.810	15000	conc and amount (average Ro literature)
Natural fertilizers	69.576	337.432	7.438	8.240	637.461	2.922	34.844	94.893	647200	conc and amount (average Ro literature)
N fertilizers	0.053	0.157	NE	0.360	0.032	0.064	0.122	0.045	3724578	conc (average European literature), amount (Ro literature)
P fertilizers	0.134	1.450	0.012	0.321	0.594	0.099	0.122	0.933	3724578	conc (average European literature), amount (Ro literature)
K fertilizers	0.002	0.006	NE	0.016	0.018	0.003	0.010	0.002	3724578	conc (average European literature), amount (Ro literature)
Atmospheric deposition	2	100	1.4	7.5	17.5	2.5	40	NE	14856800	fluxes (half of the average for Hungary)
Irrigation	0.825	4.123	NE	2.062	NE	0.041	0.206	2.062	204200	conc (Ro regulations, water class 2), amount (as described in the report)
Total input	***73.185***	***445.553***	***8.880***	***18.565***	***656.145***	***5.675***	***75.734***	***99.744***		
Outputs (as from 14856800 ha)										
Animal wastes	55.208	267.751	5.902	6.538	505.823	2.319	27.648	75.297	14329900	conc (Ro literature) amount (estimation based on Ro literature)
Animal waste water	0.877	5.857	0.399	1.438	2.752	0.252	1.604	0.655	14329900	conc (Ro literature) amount (estimation based on Ro literature)
Main plant food products	20.706	138.040	1.380	1.063	6.902	1.380	13.804	0.690	14856800	conc and amount (regulations and Ro literature)
Main animal food products	0.389	6.476	NE	NE	NE	0.013	0.065	NE	14329900	conc and amount (regulations and Ro literature)
Leaching	<1	<1	<1	<1	<1	<1	<1	<1	NE	fluxes (Ro literature as described in the report)
Total output	***77.179***	***418.124***	***7.682***	***9.039***	***515.477***	***3.964***	***43.121***	***76.643***		
Balance	**-3.994**	**27.430**	**1.198**	**9.526**	**140.668**	**1.711**	**32.613**	**23.101**		

Figure 1 Pert diagram of the METAGRO project.



As the start of this project overlapped with start of the financial crisis, we concentrated in the first year of the project on regional and local, farm level research. Copsa Mica area was chosen because of the large number of contaminated agrosystems, and because is a key area in need for risk assessment in Romania (Barbu et al. 2006). There are attempts to find remediation solutions in this area (Barbu et al. 2001, Barbu 2007), and some plants seem feasible for soil use without risk for human health (Barbu et al 2009). However, most of the area is still used for agricultural crops. A preliminary desk study revealed the lack of published spatially explicit data concerning the distribution of metal in the agricultural soils, despite the relatively large number of projects run in the area over the time. Consequently we decided to perform as a first step a screening of the distribution of metals in soil and crops around Copsa Mica. The details of the sampling program with the exact location of each sampling point are presented in figure 2. Soil was sampled from 0-20 cm level. Occasionally organic and mineral layers were separated (layer 1 and layer 2), and sediment from streams and river was sampled. Samples were wet digested (aqua regia) with a Perkin-Elmer Anton-Paar Multiwave 3000 system, and analyzed with a Perkin-Elmer Elan DRC-e ICP-MS. Quality control was performed with certified reference materials BCR 142R and BCR 320R.

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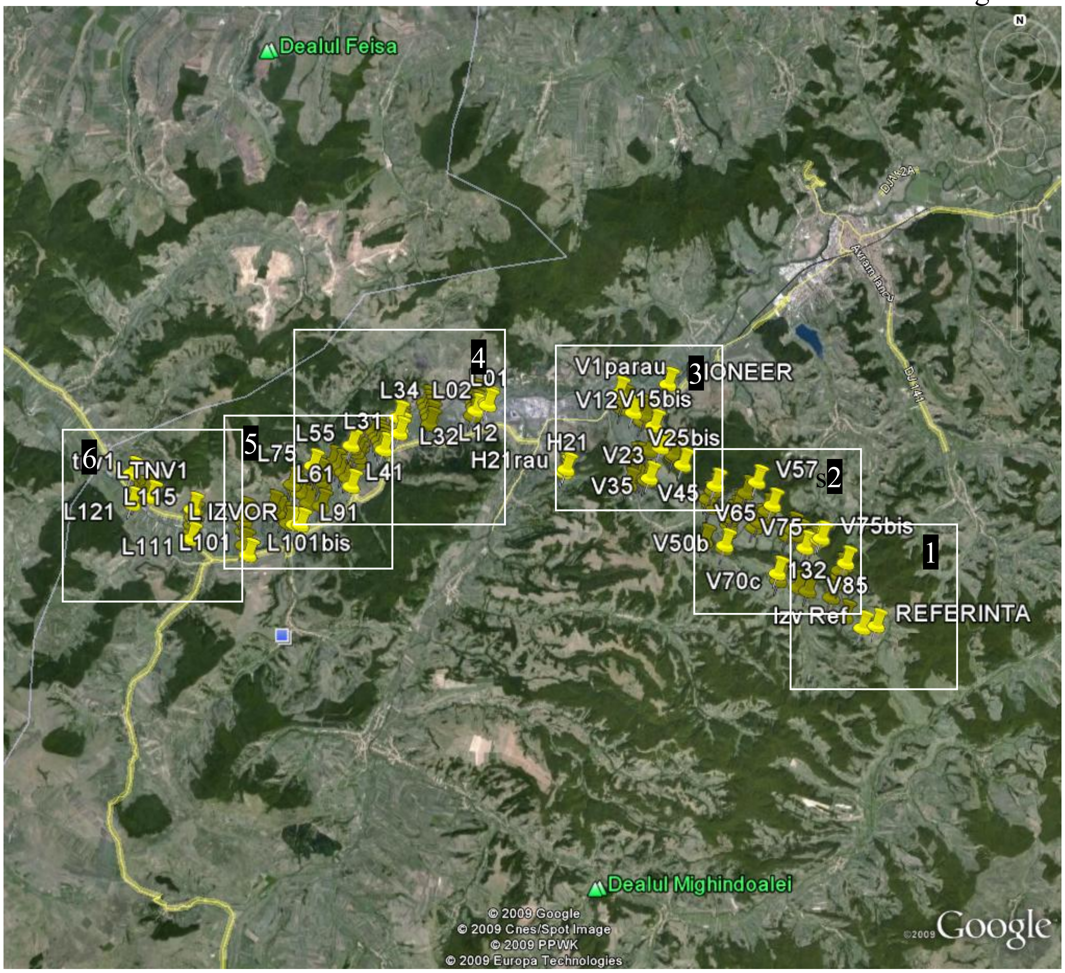
Figura 1 Overall and detailed location of the sampling points in Copsa Mica area (image source: Google Earth).



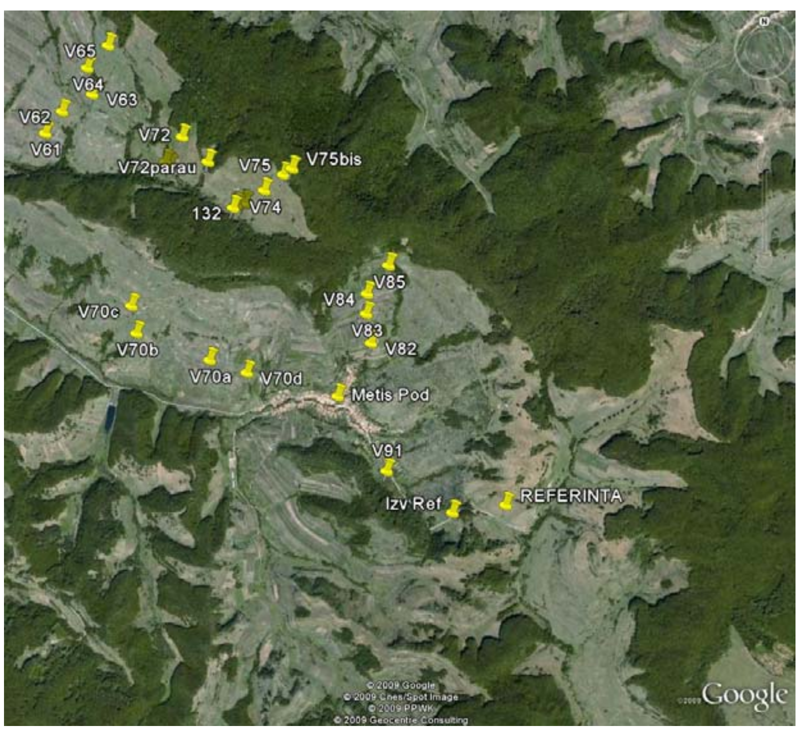


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Figure 1 Continued

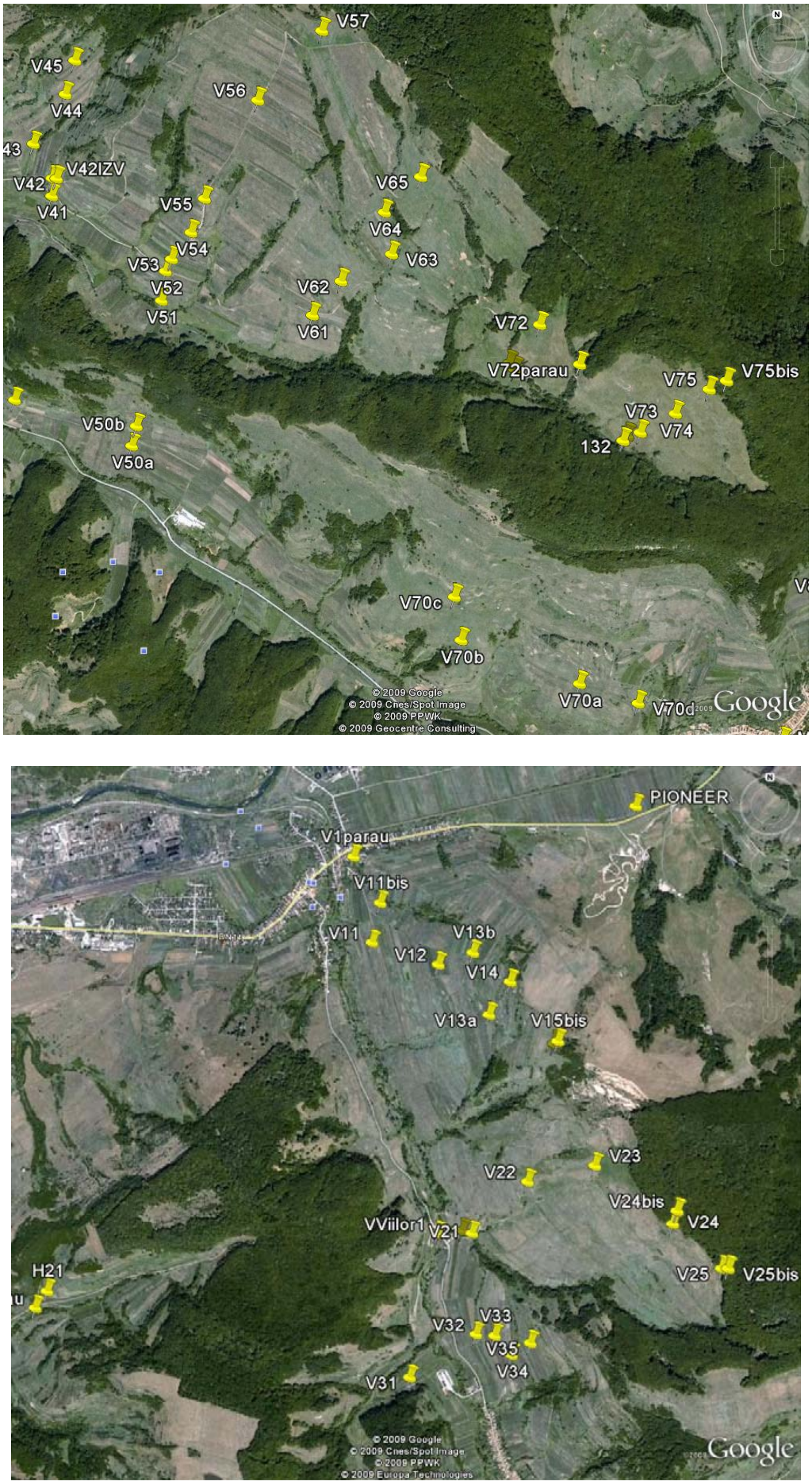
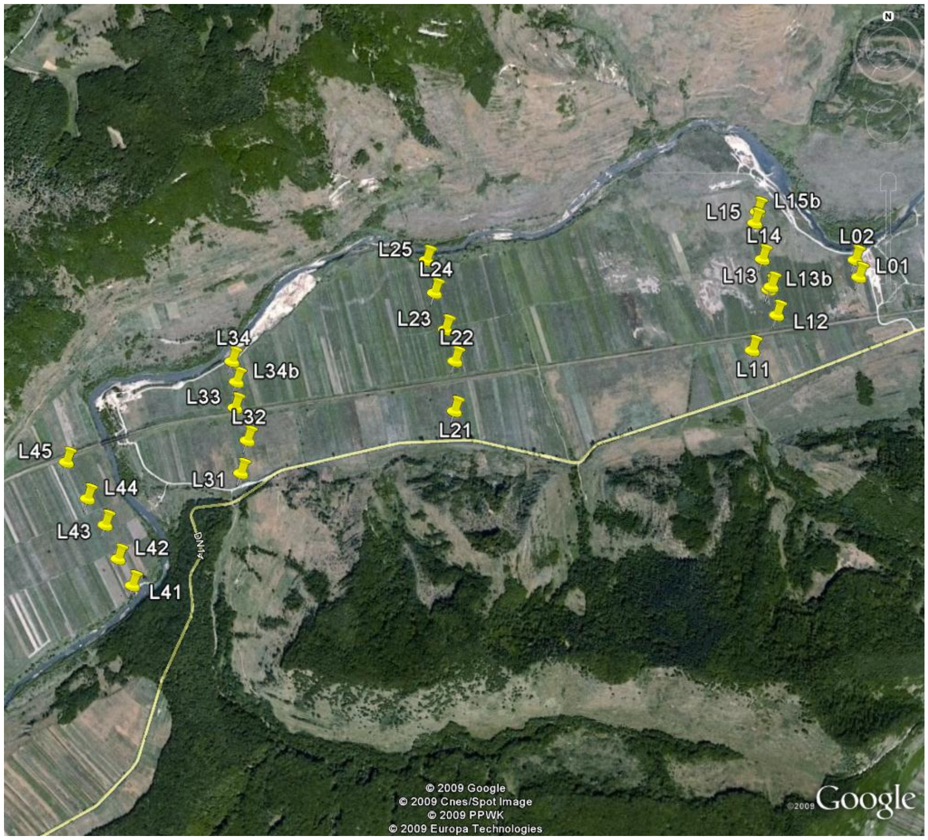


Figure 1 Continued



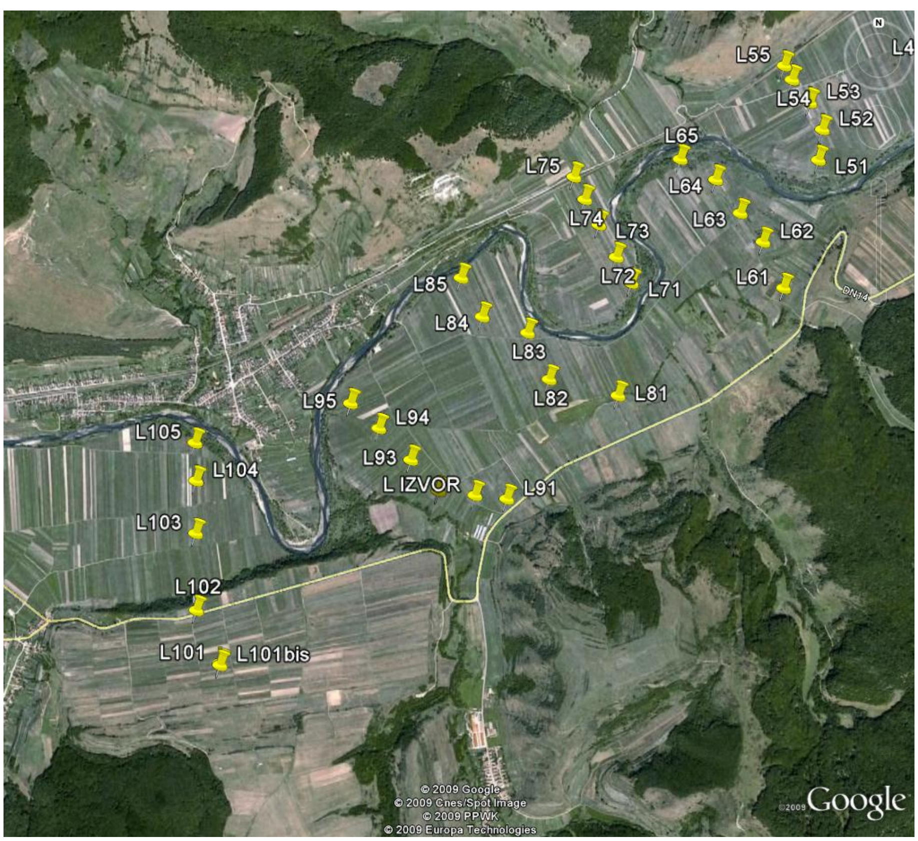


Figure 1 Continued

Concentrations of elements characterizing each sampling point are presented in table 2 (selected elements). It is not our purpose here to interpret these screening data, because they have to be complement with other soil parameters. We can however remark, beside the normal decreasing gradients with distance, large concentrations in the organic layer at the forest margin near agrosystems (suggesting the barrier effect of the forest), or large concentrations in the sediments of small streams in catchments rich in agrosystems (suggesting that an important erosion took place in time and transferred the elements in the aquatic system). Further research steps include completing the analyses of plant tissues (maize) sampled at the same points, and inventory of the farm types and agricultural practices, the selection of the model farms on a gradient of contamination in order to build farm gate balances of elements, and the quantification (and eventually historical reconstruction) of the export of microelements by erosion from the studied catchment.

In conclusion, we provide here the first public spatially referenced data set in the Copsa Mică area, following the principle "public money – public data". The full set of elements concentrations, and all other data which will be obtained in the project will be part of an on-line data base coupled with the detailed digital terrain model of the area on the project site, www.metagro.cesec.ro.

Table 2 Distribution of microelements in soil and sediment samples.

Code	As µg/g	Cd µg/g	Co µg/g	Cr µg/g	Cu µg/g	Mn µg/g	Ni µg/g	Pb µg/g	V µg/g	Zn µg/g
L1.1	18.32	20.62	UDL	71.47	25.96	340.9	33.80	557.3	32.76	969.0
L1.2	24.80	29.12	0.402	81.35	46.98	344.5	38.27	971.2	43.07	1454
L1.3	28.55	34.49	0.427	71.93	61.77	401.1	37.32	1439	38.68	1721
L1.4	43.05	50.21	1.924	81.51	94.29	458.3	40.19	2117	48.07	834.0
L1.5	53.92	52.01	1.347	78.10	114.6	421.0	34.92	2863	44.95	1205
L1.5bis	44.72	33.11	0.484	77.37	114.4	344.4	36.05	2923	44.37	1585
L1.3bis	30.46	29.08	0.049	75.04	68.88	406.7	31.35	1629	39.49	1254
L2.1	19.15	16.50	2.420	87.99	33.50	479.7	47.77	668.1	58.91	844.2
L2.2	32.78	27.61	3.454	94.51	59.57	529.6	50.70	1028	61.90	1379
L2.3	37.73	36.95	3.503	96.13	77.77	535.8	50.18	1694	60.59	1938
L2.4	46.75	39.59	1.576	78.93	85.89	438.4	39.33	1979	45.33	1048
L2.5	39.62	32.15	0.669	71.73	71.45	397.6	34.55	1843	40.46	1743
L3.1	17.12	15.78	0.079	74.90	36.49	379.0	41.99	698.1	44.20	851.8
L3.2	17.76	17.20	0.845	79.46	31.38	394.8	38.31	695.0	48.13	897.7
L3.3	25.24	24.19	1.421	82.54	53.72	428.6	41.09	1041	52.91	1258
L3.4	24.73	21.95	0.940	74.67	43.59	431.9	37.78	1017	43.61	1104
L3.5	29.03	20.37	0.176	66.12	44.54	391.5	33.59	1042	37.95	1074
L4.1	12.60	8.38	UDL	71.58	12.88	364.0	31.63	348.2	38.23	453.0
L4.2	18.66	15.27	UDL	71.21	25.29	309.9	25.54	751.8	35.28	843.7
L4.3	13.98	2.85	1.832	90.18	15.31	517.7	46.08	108.7	60.10	149.8
L4.4	25.44	22.36	UDL	70.57	45.81	401.4	33.81	1203	37.48	1215
L4.5	24.01	22.49	UDL	71.86	43.52	441.7	33.63	1131	37.81	1127
L5.1	32.95	17.35	UDL	63.31	36.82	321.5	27.28	814.8	32.87	943.8
L5.2	28.25	19.13	1.883	83.76	42.75	453.6	41.34	962.5	51.12	1030
L5.3	19.85	18.38	1.020	69.80	34.59	435.0	36.72	784.3	45.42	859.3
L5.4	24.99	20.03	0.812	79.29	49.07	434.4	39.43	1096	50.28	1060
L5.5	24.18	20.41	2.724	87.17	45.46	517.1	50.02	1043	60.16	1028
L6.1	12.24	4.416	2.630	85.86	13.82	547.7	42.30	211.3	56.22	235.0
L6.2	15.23	5.986	2.783	87.90	18.74	460.2	48.67	319.2	60.28	338.8
L6.3	23.78	14.90	UDL	68.06	28.31	358.1	31.26	789.4	35.24	787.9
L6.4	19.93	12.49	UDL	60.27	23.15	338.8	27.10	742.1	28.65	718.8
L6.5	24.66	11.82	UDL	64.74	22.91	338.3	29.16	583.1	33.72	619.7
L7.1	20.22	10.07	UDL	58.50	18.32	325.4	27.58	499.7	32.71	537.8
L7.2	17.34	7.468	UDL	61.92	14.01	306.9	24.45	436.4	30.18	425.9
L7.3	17.27	6.581	UDL	62.20	12.36	326.3	27.26	359.5	29.67	358.3
L7.4	24.28	10.10	1.476	84.60	24.50	453.3	41.88	460.0	52.04	530.0
L7.5 forest layer 1	15.61	3.841	4.928	98.57	22.24	612.4	59.28	187.5	72.26	209.0
L8.1	12.50	4.636	1.423	85.21	19.35	550.4	41.13	227.8	56.40	268.7
L8.2	21.90	10.19	1.678	94.55	23.66	462.6	48.45	447.2	54.29	542.1
L8.3	23.01	10.44	UDL	73.89	21.53	382.7	37.88	517.0	39.20	564.2
L8.4	20.95	9.572	0.139	71.57	21.39	406.9	34.08	504.9	44.91	517.5
L8.5	17.87	8.075	0.017	69.62	17.30	406.8	35.23	405.2	41.59	420.8
L9.1	11.18	4.107	UDL	64.46	14.95	456.7	34.76	192.3	44.13	226.2
L9.2	11.89	4.918	1.488	76.63	18.67	575.1	40.18	236.4	57.64	279.5
L9.3	14.48	3.218	4.004	97.23	18.34	517.9	49.72	158.0	75.00	202.7
L9.4	17.19	9.126	3.071	95.32	23.84	507.8	52.88	411.2	60.17	470.3
L9.5	21.63	11.20	4.787	116.70	31.65	626.9	58.68	469.0	78.68	524.5
L10.1	13.00	2.932	1.957	91.14	11.11	488.9	45.74	156.0	60.86	188.2
L10.1bis	13.15	2.401	2.766	96.81	10.00	507.9	46.39	129.3	63.04	155.4
L10.2	10.66	4.110	2.462	65.00	13.23	606.8	31.18	219.3	41.54	224.8
L10.3	12.90	4.690	1.179	79.47	14.10	471.5	39.36	223.3	50.94	271.2
L10.4	14.94	7.959	1.114	82.30	16.41	453.5	39.70	371.8	48.89	420.5
L10.5	14.34	6.840	1.266	80.76	16.84	468.1	40.54	356.5	50.17	363.6
L11.1	10.20	4.499	UDL	61.63	10.21	335.3	27.03	213.0	38.37	272.5
L11.2	15.80	5.126	4.269	106.42	21.66	566.1	53.53	239.4	75.69	283.0
L11.3	16.83	6.630	4.565	110.62	27.09	561.3	54.97	324.2	82.47	351.6

Table 2 Continued.

Code	As µg/g	Cd µg/g	Co µg/g	Cr µg/g	Cu µg/g	Mn µg/g	Ni µg/g	Pb µg/g	V µg/g	Zn µg/g
L11.4	13.90	5.036	1.361	84.49	15.67	452.4	39.97	245.9	54.46	270.3
L11.5	12.56	4.786	0.548	79.35	12.89	509.8	34.19	240.6	47.33	283.8
L12.1	18.93	4.628	4.378	129.08	25.43	512.6	62.37	208.1	97.53	270.7
L12.2	13.61	4.391	0.528	80.86	12.84	405.2	38.36	188.7	53.50	241.4
L12.3	15.20	4.635	0.942	83.80	12.40	430.9	39.30	195.8	49.30	253.2
L12.4	18.72	5.671	UDL	80.57	11.66	369.6	36.50	277.8	40.27	301.5
L12.5	17.74	5.825	UDL	60.89	11.03	323.2	27.40	244.4	33.57	274.2
L0.1	33.00	38.60	0.623	80.72	64.19	399.4	39.90	1432	47.34	1981
L0.2	71.62	65.12	4.127	98.05	118.5	490.0	51.10	2496	64.27	504.1
V reference	10.21	1.425	UDL	81.92	3.495	318.6	33.83	51.89	46.56	73.99
V1.1	17.32	9.801	2.771	99.89	22.25	603.3	44.57	432.2	63.35	455.2
V1.1bis	16.51	10.44	2.727	86.44	24.84	706.1	46.07	449.2	57.44	472.5
V1.2	15.84	6.578	3.985	94.06	18.99	694.6	53.05	302.3	66.40	302.4
V1.3 a	12.09	4.606	1.018	155.25	11.16	467.2	236.62	216.0	49.04	199.2
V1.4	17.35	9.521	3.383	81.08	21.38	454.0	40.06	396.5	57.76	395.8
V1.5	12.17	3.106	2.403	75.30	51.16	431.7	42.46	142.8	55.51	168.3
V1.5 bis layer 1	23.74	40.58	0.597	77.81	79.72	362.7	31.32	1712	47.39	1635
V1.5 bis layer 2	12.66	1.000	3.042	79.42	22.63	455.0	44.62	15.94	52.86	65.03
v2.1 bis	14.00	2.821	2.251	84.59	17.00	533.4	44.33	118.2	61.13	152.4
v2.2	12.48	4.254	1.182	77.03	10.70	527.9	38.57	167.7	50.40	180.6
V2.3	8.97	2.550	0.430	143.84	0.708	367.8	81.56	104.8	36.28	80.04
V2.4	11.32	2.629	0.841	80.42	12.79	400.3	37.47	109.7	52.29	128.0
V2.4 BIS layer 1	24.76	22.68	2.459	102.64	33.54	1041.2	43.06	1004	62.28	772.6
V2.4 BIS layer 2	12.01	2.289	2.241	76.32	10.41	542.4	41.96	123.0	53.90	133.5
V2.5 layer 1	23.58	25.20	0.087	65.12	37.85	844.4	24.64	1410	40.76	788.3
V2.5 layer 2	6.43	0.196	UDL	53.05	1.915	215.0	28.90	45.65	39.59	28.23
V3.2	9.75	1.722	2.739	57.46	98.01	582.9	23.50	178.4	52.23	120.4
V3.3	94.20	2.822	0.817	74.90	9.769	438.5	42.04	117.9	48.79	348.5
V3.4	11.48	3.009	1.097	70.40	9.621	503.3	35.33	100.4	46.50	139.1
V3.5	10.44	2.568	0.744	66.64	11.55	368.9	39.47	110.6	49.18	129.0
V4.0	10.18	2.599	0.344	107.00	9.035	409.1	307.45	59.99	44.37	124.1
V4.1	9.11	1.482	1.350	60.92	13.89	483.3	34.11	73.36	53.30	85.22
V4.2	13.24	1.752	0.319	80.18	8.172	620.9	37.70	71.95	45.28	114.7
V4.3	12.61	2.029	0.948	72.97	10.40	480.6	35.25	69.06	52.75	100.4
V4.4	13.29	1.789	1.830	86.25	10.06	516.1	41.09	54.07	53.66	102.0
V4.5	11.79	1.206	1.670	82.78	26.94	509.8	43.63	57.34	57.36	85.19
V5.0 layer 1	12.65	1.391	8.690	95.06	23.36	635.7	44.79	32.94	63.90	88.74
V5.0 layer 2	10.97	1.487	8.814	98.50	38.73	567.4	43.97	39.10	65.56	89.41
V 5.1	12.44	1.858	12.30	107.88	26.35	1836.8	45.49	46.23	87.49	107.5
V5.2	21.02	2.071	9.728	125.08	33.85	931.3	57.75	53.48	69.13	116.0
V5.3	11.71	2.607	9.639	108.54	48.89	810.4	50.62	42.40	74.09	171.9
V5.4	13.17	1.574	10.04	115.86	27.97	722.6	51.36	37.73	76.31	212.2
V5.5	13.05	1.492	9.524	114.41	21.95	547.4	56.74	41.66	69.82	113.6
V5.6	14.15	1.746	9.511	107.17	25.52	611.3	49.59	38.49	79.39	103.8
V5.7	16.49	1.655	13.66	121.95	24.97	1081	53.36	63.34	85.98	104.8
V6.1	15.61	2.609	7.892	124.73	21.17	452.8	48.79	40.46	63.44	134.2
V6.2	10.91	1.805	7.339	112.45	17.03	586.3	46.32	41.58	60.24	107.3
V6.3	11.76	1.926	8.522	110.11	21.51	561.4	40.77	34.27	69.75	95.52
V6.4	12.69	1.355	11.73	119.70	27.37	625.2	49.64	41.67	96.27	116.9
V6.5	16.22	1.678	7.300	143.20	15.38	522.0	63.37	33.08	57.87	107.5
V7.0 a	11.76	1.544	9.227	111.04	20.63	826.9	42.83	36.09	72.34	81.19
V7.0 b	13.06	1.608	8.952	117.36	59.37	725.1	53.95	55.28	70.64	97.43
V7.0 c	12.54	2.260	9.109	121.81	114.32	689.7	55.92	37.87	70.42	126.9
V7.0 d	13.01	1.497	8.089	113.52	28.77	641.9	50.78	38.91	65.50	111.2
V7.1	11.63	1.410	6.524	102.55	18.53	599.5	43.16	47.89	56.92	154.8
V7.2	11.50	2.397	6.133	103.98	11.95	488.1	40.38	46.13	51.84	125.9
V7.3	10.43	2.185	7.335	89.32	17.41	609.5	33.47	63.17	64.99	90.40
V7.4	11.68	2.417	8.440	86.24	21.16	741.0	36.86	55.11	68.95	108.4
V7.5	14.64	2.606	7.591	89.62	16.19	522.8	43.54	58.43	64.84	112.9

Table 2 Continued.

	As	Cd	Co	Cr	Cu	Mn	Ni	Pb	V	Zn
Code	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
V 7.5 layer 1	11.86	2.417	7.012	84.64	23.03	544.1	39.98	139.3	63.12	111.8
V 7.5 layer 2	16.53	5.900	9.149	85.63	15.99	533.8	40.46	13.39	62.51	217.6
V8.2	10.31	0.434	7.999	80.52	34.03	621.3	44.03	41.80	69.96	56.08
V8.3	11.95	1.207	7.486	89.34	14.39	581.4	44.05	19.61	59.80	168.2
V8.4	9.860	0.774	7.184	79.81	14.01	537.1	40.45	24.99	57.17	64.04
V8.5	10.21	0.998	7.121	81.49	16.24	530.2	38.08	20.85	63.44	66.19
V9.1	14.54	1.279	8.154	88.36	18.40	610.5	43.38	27.12	70.42	76.72
Pioneer	11.27	0.770	5.044	94.58	18.83	578.8	38.83	124.9	44.17	68.05
H2.1	13.21	5.100	4.825	71.44	23.57	421.6	31.41	116.8	46.82	231.6
V1.3 b	10.94	5.149	8.509	67.98	28.43	674.4	35.11	174.6	66.41	220.9
V2.1	15.53	7.893	9.783	91.80	26.35	740.7	45.11	64.01	75.68	357.9
V2.4 strat 2	15.08	2.473	7.855	92.39	17.00	492.3	54.40	13.77	65.64	135.7
V2.5	10.59	0.342	1.684	91.91	4.66	319.3	46.43	64.79	29.83	64.48
V3.1	7.291	2.195	6.266	60.66	12.79	498.1	14.14	22.04	55.39	70.76
H 2.1 sediment	12.49	0.940	16.10	89.28	154.81	3857	40.21	600.8	51.06	68.74
V. Viilor sediment	72.70	26.09	8.862	59.83	131.39	624.2	43.87	1469	62.81	1124
Metis sediment	46.69	57.40	2.893	87.93	35.17	325.8	44.84	59.69	35.47	5.76
V7.2 stream sediment	11.85	1.100	9.558	71.24	18.11	748.1	23.95	22.09	72.44	481.1
V7.3 stream sediment	11.68	0.610	2.441	90.97	3.06	480.8	50.33	15.31	29.93	71.10
TNV 1 sediment	16.83	1.073	3.577	115.9	11.17	454.3	57.13	57.40	37.36	113.8
V5.1 sediment	12.69	3.399	11.51	57.63	23.29	2108	23.79	37.73	91.97	192.0

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References

Barbu, H., 2007, Remediation and sustainable development of the soil polluted with heavy metals in Copsa Mica area, Research project, http://www.rutsolmeg.ro/

C.H. BARBU, R. GROVU*, Phytoremediation of the Soils Contaminated with Heavy Metals in Copsa Mica Area-Romania*, in Contaminated Soils, Vol. 6, P.K. KOSTECKI, E.J. CALABRESE AND J. DRAGUN (Eds.), CRC Press, Amherst, MA, p. 69-78, 2001

Barbu**,** C.H. Pavel B.-P., Sand C., Pop M.R., *Miscanthus sinensis giganteus' behaviour on soils polluted with heavy metals, Metal Elements in Environment, Medicine and Biology*, Tome IX, pp. 21-24, Cluj University Press, 2009 (Proc. of 9th Int. Symp. of Roumanian Academy - Branch Cluj-Napoca, 2009, October 16-17, Cluj-Napoca, Romania).

Iordache, V. Dumitru, M., Estimation of the balance of heavy metals in Romanian agro-ecosystems and research directions, 2010, Agric. Ecosys. Environ, submitted