

Urban Soil Contamination in Rome: Insights from XRF and Multivariate Analysis

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Supplementary Materials

Table S1: Characteristics of the 59 sampling locations.

Sl.No.	Soil Name	Abbreviation	Coordinates	ESA World Cover
1	Ostia Antica 2 Volponi AC2	OA2V.AC2	(41.7601, 12.2982)	Grassland
2	Mariotti 3 cereals AC2	M3C.AC2	(41.81603, 12.35356)	Cropland
3	Mongale 1 Cereals VS3	M1C.VS3	(41.748, 12.5393)	Grassland
4	Mongale 2 Prato VS3	M2P.VS3	(41.748, 12.5393)	Grassland
5	Ostia Antica Volponi 1 AC2	OAV1.AC2	(41.7599, 12.298)	Tree cover
6	Colline di Veio 2 SR1	CdV2.SR1	(42.0319, 12.3856)	Cropland
7	Fiumicino 1	F1	(41.8008, 12.3083)	Grassland
8	Mongale 5 Prato VS3	M5P.VS3	(41.7386, 12.53)	Cropland
9	Mariotti 1 Ortaggi AC2	M1O.AC2	(41.816, 12.3536)	Cropland
10	Mongale 3 Prato Naturale IN	M3PN.IN	(41.7574, 12.5543)	Grassland
11	Ostia Antica 4 AC2	OA4.AC2	(41.7621, 12.2925)	Tree cover
12	Ostia 1 DU1	O1.DU1	(41.7444, 12.2866)	Grassland
13	Colline di Veio 1 SR1	CdV1.SR1	(42.0308, 12.3862)	Grassland
14	Parco di Veio 1 Cereals VU4	PdV1C.VU4	(42.0264, 12.3953)	Cropland
15	Mongale 4 Oliveto Foto SR1	M4OF.SR1	(41.7493, 12.5326)	Grassland
16	Ostia Antica 3 Volponi	OA3V	(41.8147, 12.2972)	Cropland
17	Ostia Antica Aldobrandi 5 AC2	OAA5.AC2	(41.7613, 12.2923)	Tree cover
18	Colline di Veio 3 Soil Sottile SR1	CdV3SS.SR1	(42.03, 12.3858)	Shrubland
19	Prato Parco di Veio 3 VU4	PPdV3.VU4	(42.0276, 12.3909)	Cropland
20	Parco di Veio 2 VU4	PdV2.VU4	(42.0264, 12.3928)	Cropland
21	Mariotti 2 Prato AC2	M2P.AC2	(41.816, 12.3536)	Cropland
22	Marcigliana 5 VU3	M5.VU3	(42.00048, 12.56825)	Grassland
23	Tenuta Columba Salaria 2 AC3	TCS2.AC3	(42.03885, 12.55613)	Cropland
24	Settebagni 4 AC2	S4.AC2	(42.00625, 12.51187)	Cropland
25	Tenuta Columba Salaria 1 AC3	TCS1.AC3	(42.0384, 12.55583)	Grassland

26	Marcigliana 8 AN2	M8.AN2	(41.99146, 12.56138)	Cropland
27	Marcigliana 3 VU3	M3.VU3	(41.99581, 12.56434)	Shrubland
28	Settebagni 6 AC1	S6.AC1	(42.00633, 12.51045)	Cropland
29	Marcigliana 6 VU3	M6.VU3	(42.0008, 12.56827)	Grassland
30	Marcigliana 7 AN2	M7.AN2	(41.99176, 12.56096)	Cropland
31	Marcigliana 9 AN2	M9.AN2	(41.99184, 12.56154)	Cropland
32	Marcigliana 1 VU3	M1.VU3	(41.99625, 12.56437)	Grassland
33	Marcigliana 2 VU3	M2.VU3	(41.99614, 12.56416)	Grassland
34	Marcigliana 4 VU3	M4.VU3	(42.00011, 12.56808)	Cropland
35	Settebagni 2 AC1	S2.AC1	(42.00649, 12.5081)	Cropland
36	Settebagni 1 AC1	S1.AC1	(42.00642, 12.50836)	Cropland
37	Settebagni 5 AC2	S5.AC2	(42.00631, 12.51202)	Cropland
38	Settebagni 3 AC2	S3.AC2	(42.00677, 12.51193)	Cropland
39	Tenuta Columba Salaria 3 AC3	TCS3.AC3	(42.03927, 12.55616)	Cropland
40	60 Via Cherasco VU2	60VC.VU2	(41.95411, 12.34489)	Tree cover
41	49 Via m. Visentini VS2	49VmV.VS2	(42.06189, 12.35241)	Grassland
42	41 Cesano EST VU2	41CE.VU2	(42.07572, 12.35827)	Cropland
43	46 Via di Baccanello VS2	46VdB.VS2	(42.06055, 12.35563)	Tree cover
44	58 Via m. Filippini GG1	58VmF.GG1	(41.93446, 12.35094)	Grassland
45	55 Via della Storta GG1	55VdS.GG1	(41.93302, 12.35063)	Grassland
46	42 Cesano EST VU2	42CE.VU2	(42.07656, 12.35773)	Grassland
47	54 Via di Casal Secco AN1	54VdCS.AN1	(41.92413, 12.35389)	Cropland
48	59 Via Cherasco GG1	59VC.GG1	(41.9538, 12.34439)	Tree cover
49	52 Olgiata NORD VU1	52ON.VU1	(42.05254, 12.37427)	Cropland
50	53 Viadi Casal Selce AN1	53VCS.AN1	(41.92457, 12.35438)	Cropland
51	44 Cesano EST VU2	44CE.VU2	(42.07139, 12.3541)	Shrubland
52	57 Via m. Filippini GG1	57VmF.GG1	(41.93367, 12.35087)	Grassland

53	47 Via di Baccanello VS2	47VdB.VS2	(42.0611, 12.35604)	Cropland
54	48 Via di Baccanello VS2	48VdB.VS2	(42.06095, 12.3562)	Grassland
55	45 Via di Baccanello VS2	45VdB.VS2	(42.06048, 12.35544)	Grassland
56	50 Via m. Visentini VU6	50VmV.VU6	(42.06212, 12.35188)	Cropland
57	51 Olgiata NORD VU6	51ON.VU6	(42.05161, 12.37437)	Cropland
58	43 Cesano EST VU2	43CE.VU2	(42.07304, 12.35718)	Grassland
59	56 Via della Storia GG1	56VdS.GG1	(41.93335, 12.35071)	Cropland

Abbreviation- OA2V — Ostia Antica 2 Volponi, M3C — Mariotti 3 cereals, M1C — Mongale 1 Cereals, M2P — Mongale 2 prato, OAV1 — Ostia Antica Volponi1, CV2 — Colline di Veio 2, F1 — Fiumicino 1, M5P — Mongale 5 Prato, M1O — Mariotti 1 Ortaggi, M3PN — Mongale 3 Prato Naturale, OA4 — Ostia Antica 4, O1 — Ostia 1, CV1 — Colline di Veio 1, PV1C — Parco di Veio 1 Cereals, M4OF — Mongale 4 Oliveto Foto, OA3V — Ostia Antica 3 Volponi, OAA5 — Ostia Antica Aldobrandi 5, CV3SS — Colline di Veio 3 Soil Sottile, PPV3 — Prato Parco di Veio 3, PV2 — Parco di Veio 2, M2P — Mariotti 2 Prato, M5 — Marcigliana 5, TCS2 — Tenuta Columba Salaria 2, S4 — Settebagni 4, TCS1 — Tenuta Columba Salaria 1, M8 — Marcigliana 8, M3 — Marcigliana 3, S6 — Settebagni 6, M6 — Marcigliana 6, M7 — Marcigliana 7, M9 — Marcigliana 9, M1 — Marcigliana 1, M2 — Marcigliana 2, M4 — Marcigliana 4, S2 — Settebagni 2, S1 — Settebagni 1, S5 — Settebagni 5, S3 — Settebagni 3, TCS3 — Tenuta Columba Salaria 3, 60VC — 60 Via Cherasco, VmV — Via m. Visentini, 41CE — 41 Cesano EST, VB — Via di Baccanello, 58VmF — 58 Via m. Filippini, VS—Via della Storta, 42CE — 42 Cesano EST, VCS—Via di Casal Secco, 59VC—59 Via Cherasco, 52ON— 52 Olgiata NORD, 53VCS— 53 Via di Casal Selce, 44CE— 44 Cesano EST, 57VmF— 57 Via m. Filippini, 47VB— 47 Via di Baccanello, 48VB— 48 Via di Baccanello, 45VB— 45 Via di Baccanello, 50VmV— 50 Via m. Visentini, 51ON— 51 Olgiata NORD, 43CE— 43 Cesano EST, 56VdS — 56 Via della Storia

Table S2: XRF Results of Soil Samples from Rome (mg/kg) for Various Elements

Soil Name	Latitude	Longitude	K	Ca	Ti	V	Cr	Mn	Fe	Ni	Cu
Ostia Antica 2 Volponi AC2	41.7601	12.2982	17381	67698	3774	104	74	913	35795	44	38
Mariotti 3 cereals AC2	41.81603	12.35356	17902	52960	4560	130	67	1107	39505	35	27
Mongale 1 Cereals VS3	41.748	12.5393	16784	43359	5376	355	79	1370	52775	26	55
Mongale 2 Prato VS3	41.748	12.5393	11765	25161	6022	345	114	1555	59498	28	64
Ostia Antica Volponi 1 AC2	41.7599	12.298	16848	36776	3814	113	63	907	40381	38	75
Colline di Veio 2 SR1	42.0319	12.3856	8279	15222	4646	200	77	1231	51421	39	48
Fiumicino 1	41.8008	12.3083	16750	79954	3666	76	90	915	31578	43	21
Mongale 5 Prato VS3	41.7386	12.53	6468	26722	5555	303	78	1323	54173	21	46
Mariotti 1 Ortaggi AC2	41.816	12.3536	18142	71993	3553	78	83	727	34388	44	35
Mongale 3 Prato Naturale IN	41.7574	12.5543	10933	29890	5297	274	68	1240	50727	24	54
Ostia Antica 4 AC2	41.7621	12.2925	14779	60009	3091	0	75	737	29910	43	21
Ostia 1 DU1	41.7444	12.2866	8799	123059	3492	114	134	1118	40881	43	0
Colline di Veio 1 SR1	42.0308	12.3862	9423	20900	4653	173	68	1099	50722	28	59
Parco di Veio 1 Cereals VU4	42.0264	12.3953	24728	20790	3977	128	<DL	1401	39529	21	45
Mongale 4 Oliveto Foto SR1	41.7493	12.5326	8302	16255	6147	346	128	1395	61732	33	96
Ostia Antica 3 Volponi	41.8147	12.2972	14824	78929	3442	111	<DL	894	38343	34	304
Ostia Antica Aldobrandi 5 AC2	41.7613	12.2923	17331	70335	3939	81	105	926	36655	54	32

Colline di Veio 3 Soil Sottile SR1	42.03	12.3858	16899	19006	4231	172	<DL	1435	44412	27	31
Prato Parco di Veio 3 VU4	42.0276	12.3909	27598	25490	5992	243	80	1502	59637	28	78
Parco di Veio 2 VU4	42.0264	12.3928	5192	89535	15096	1738	13876	2121	62006	3234	146
Mariotti 2 Prato AC2	41.816	12.3536	16015	57999	3910	133	0	842	38228	38	32
Marcigliana 5 VU3	42.00048	12.56825	13303	7795	5185	206	112	1217	53294	32	24
Tenuta Columba Salaria 2 AC3	42.03885	12.55613	16168	76677	3137	70	88	629	31232	37	24
Settebagni 4 AC2	42.00625	12.51187	6460	94114	14458	1500	11626	1973	60027	2753	123
Tenuta Columba Salaria 1 AC3	42.0384	12.55583	18721	74040	3978	110	109	784	46521	61	30
Marcigliana 8 AN2	41.99146	12.56138	14767	15771	5324	191	84	1272	46238	33	33
Marcigliana 3 VU3	41.99581	12.56434	16417	15624	5453	225	101	1408	52552	25	31
Settebagni 6 AC1	42.00633	12.51045	3220	99523	17394	1952	15122	2163	62414	3512	152
Marcigliana 6 VU3	42.0008	12.56827	15529	13093	5853	259	134	1433	56830	44	35
Marcigliana 7 AN2	41.99176	12.56096	3191	96360	17816	1957	14975	1937	58828	2333	155
Marcigliana 9 AN2	41.99184	12.56154	14226	34999	4176	133	<DL	1931	39015	32	27
Marcigliana 1 VU3	41.99625	12.56437	14258	15155	4524	161	67	1340	42804	24	24
Marcigliana 2 VU3	41.99614	12.56416	16475	17158	4951	196	86	1150	46476	32	28
Marcigliana 4 VU3	42.00011	12.56808	12460	7929	4879	214	112	1243	49315	33	29
Settebagni 2 AC1	42.00649	12.5081	16488	71917	3655	70	95	932	32435	48	18
Settebagni 1 AC1	42.00642	12.50836	17970	81268	4073	96	109	1057	36615	52	23
Settebagni 5 AC2	42.00631	12.51202	16598	68443	3795	93	95	974	34032	55	18
Settebagni 3 AC2	42.00677	12.51193	16579	85690	3757	86	118	1003	32126	48	17
Tenuta Columba Salaria 3 AC3	42.03927	12.55616	17853	75674	3945	104	102	745	37444	47	24
60 Via Cherasco VU2	41.95411	12.34489	14819	6058	2352	62	<DL	441	17612	13	12
49 Via m. Visentini	42.06189	12.35241	18239	7313	4316	189	62	1120	39441	21	16

VS2											
41 Cesano EST VU2	42.07572	12.35827	22465	13752	2713	119	<DL	815	24391	<DL	13
46 Via di Baccanello VS2	42.06055	12.35563	22978	11313	4139	201	<DL	1095	35097	16	47
58 Via m. Filippini GG1	41.93446	12.35094	15493	11089	3776	110	<DL	788	34227	23	13
55 Via della Storta GG1	41.93302	12.35063	14826	72112	3884	153	<DL	951	35430	14	27
42 Cesano EST VU2	42.07656	12.35773	25449	25285	3330	131	<DL	1208	32069	15	16
54 Via di Casal Secco AN1	41.92413	12.35389	14222	12933	4388	169	58	1113	38377	22	30
59 Via Cherasco GG1	41.9538	12.34439	15665	10514	3055	76	<DL	565	23645	13	16
52 Olgiata NORD VU1	42.05254	12.37427	13886	11933	4581	192	64	1382	43373	19	19
53 Viadi Casal Selce AN1	41.92545	12.35397	17768	18513	5271	214	62	1351	44774	25	32
44 Cesano EST VU2	42.07139	12.3541	20505	50270	4232	173	<DL	1238	42932	23	39
57 Via m. Filippini GG1	41.93489	12.35117	25718	18136	4868	218	<DL	1084	41307	21	31
47 Via di Baccanello VS2	42.06148	12.35037	21638	18233	4610	209	<DL	1291	41404	19	17
48 Via di Baccanello VS2	42.06019	12.35029	22675	15354	4327	196	<DL	854	38895	16	26
45 Via di Baccanello VS2	42.06155	12.35548	31316	18778	5044	238	<DL	1495	37759	15	12
50 Via m. Visentini VU6	42.06066	12.34765	18345	6396	4737	180	60	1038	40954	21	13
51 Olgiata NORD VU6	42.05175	12.37449	18778	6803	4511	151	60	1617	38347	16	<DL

43 Cesano EST VU2	42.07112	12.35408	15420	29701	4271	183	<DL	701	42163	22	22
56 Via della Storia GG1	41.93217	12.35111	14335	11962	4475	157	53	1245	40970	24	36

Table S2 (Continuation)

Soil Name	Zn	As	Rb	Sr	Zr	Mo	Sn	Ba	Ta	Pb
Ostia Antica 2 Volponi AC2	88	<DL	156	481	173	<DL	<DL	150	<DL	82
Mariotti 3 cereals AC2	77	<DL	244	562	276	<DL	<DL	249	<DL	60
Mongale 1 Cereals VS3	67	<DL	398	1023	385	<DL	<DL	415	<DL	73
Mongale 2 Prato VS3	74	<DL	283	611	398	<DL	<DL	318	27	156
Ostia Antica Volponi 1 AC2	97	<DL	189	578	233	<DL	<DL	254	<DL	212
Colline di Veio 2 SR1	64	33	205	781	396	<DL	<DL	200	24	83
Fiumicino 1	77	<DL	134	323	155	<DL	<DL	157	21	39
Mongale 5 Prato VS3	65	<DL	212	591	370	<DL	<DL	238	<DL	116
Mariotti 1 Ortaggi AC2	97	<DL	161	316	128	<DL	<DL	<DL	22	35
Mongale 3 Prato Naturale IN	69	<DL	249	472	327	<DL	<DL	233	22	88
Ostia Antica 4 AC2	67	<DL	116	255	120	<DL	<DL	<DL	<DL	30
Ostia 1 DU1	43	<DL	50	400	240	<DL	<DL	232	<DL	24
Colline di Veio 1 SR1	62	<DL	460	817	352	<DL	<DL	206	26	59
Parco di Veio 1 Cereals VU4	79	<DL	489	1050	424	<DL	<DL	247	<DL	373
Mongale 4 Oliveto Foto SR1	81	<DL	206	409	418	<DL	<DL	337	27	170
Ostia Antica 3 Volponi	103	<DL	161	609	216	<DL	<DL	169	<DL	933
Ostia Antica Aldobrandi 5 AC2	86	<DL	149	328	151	<DL	<DL	<DL	<DL	43
Colline di Veio 3 Soil	87	30	498	891	350	<DL	<DL	193	25	77

Sottile SR1										
Prato Parco di Veio 3 VU4	113	13	412	1027	431	<DL	<DL	339	<DL	151
Parco di Veio 2 VU4	65	<DL	152	420	153	104	37	317	40	53
Mariotti 2 Prato AC2	78	<DL	202	397	192	<DL	<DL	165	<DL	51
Marcigliana 5 VU3	59	<DL	242	361	380	<DL	<DL	186	24	79
Tenuta Columba Salaria 2 AC3	74	<DL	128	243	114	<DL	<DL	<DL	22	32
Settebagni 4 AC2	71	<DL	90	243	81	100	41	292	75	<DL
Tenuta Columba Salaria 1 AC3	113	<DL	178	300	150	<DL	<DL	<DL	33	35
Marcigliana 8 AN2	81	<DL	308	448	370	<DL	<DL	229	25	90
Marcigliana 3 VU3	72	<DL	298	546	411	<DL	<DL	263	<DL	101
Settebagni 6 AC1	56	<DL	73	221	65	110	43	283	58	<DL
Marcigliana 6 VU3	72	<DL	301	510	430	<DL	<DL	270	28	96
Marcigliana 7 AN2	60	<DL	122	288	139	108	47	324	48	58
Marcigliana 9 AN2	69	<DL	265	393	289	<DL	<DL	227	<DL	71
Marcigliana 1 VU3	62	<DL	247	432	291	<DL	<DL	165	<DL	73
Marcigliana 2 VU3	64	<DL	265	503	349	<DL	<DL	216	22	76
Marcigliana 4 VU3	52	<DL	220	339	361	<DL	<DL	219	<DL	74
Settebagni 2 AC1	70	<DL	127	261	143	<DL	<DL	<DL	<DL	31
Settebagni 1 AC1	83	<DL	145	333	188	<DL	<DL	<DL	23	30
Settebagni 5 AC2	68	<DL	130	247	163	<DL	<DL	<DL	45	33
Settebagni 3 AC2	65	<DL	127	350	180	<DL	<DL	<DL	<DL	32
Tenuta Columba Salaria 3 AC3	84	<DL	150	250	128	<DL	<DL	<DL	24	34
60 Via Cherasco VU2	23	<DL	164	245	157	<DL	<DL	167	<DL	43
49 Via m. Visentini VS2	65	30	332	772	343	<DL	<DL	215	26	65
41 Cesano EST VU2	46	32	386	757	315	<DL	<DL	209	19	80

46 Via di Baccanello VS2	58	28	424	1113	328	<DL	<DL	261	<DL	72
58 Via m. Filippini GG1	42	<DL	213	332	253	<DL	<DL	203	<DL	55
55 Via della Storta GG1	82	<DL	251	638	274	<DL	<DL	173	<DL	78
42 Cesano EST VU2	74	32	781	1829	357	<DL	<DL	224	23	57
54 Via di Casal Secco AN1	62	30	315	649	334	<DL	<DL	241	24	69
59 Via Cherasco GG1	31	8	188	344	201	<DL	<DL	169	0	55
52 Olgiata NORD VU1	67	35	298	828	357	<DL	<DL	198	31	77
53 Viadi Casal Selce AN1	65	31	395	897	360	<DL	<DL	296	<DL	78
44 Cesano EST VU2	69	<DL	456	1670	339	<DL	<DL	284	<DL	52
57 Via m. Filippini GG1	118	35	544	1396	437	<DL	<DL	286	<DL	99
47 Via di Baccanello VS2	66	31	476	1468	375	<DL	<DL	303	<DL	80
48 Via di Baccanello VS2	108	32	479	1247	399	<DL	<DL	275	25	84
45 Via di Baccanello VS2	70	<DL	557	1673	385	<DL	<DL	337	26	85
50 Via m. Visentini VU6	61	<DL	335	774	333	<DL	<DL	234	22	66
51 Olgiata NORD VU6	61	28	310	537	284	<DL	<DL	137	<DL	67
43 Cesano EST VU2	62	30	394	1347	325	<DL	<DL	249	25	46
56 Via della Storia GG1	67	31	359	631	341	<DL	<DL	254	<DL	83

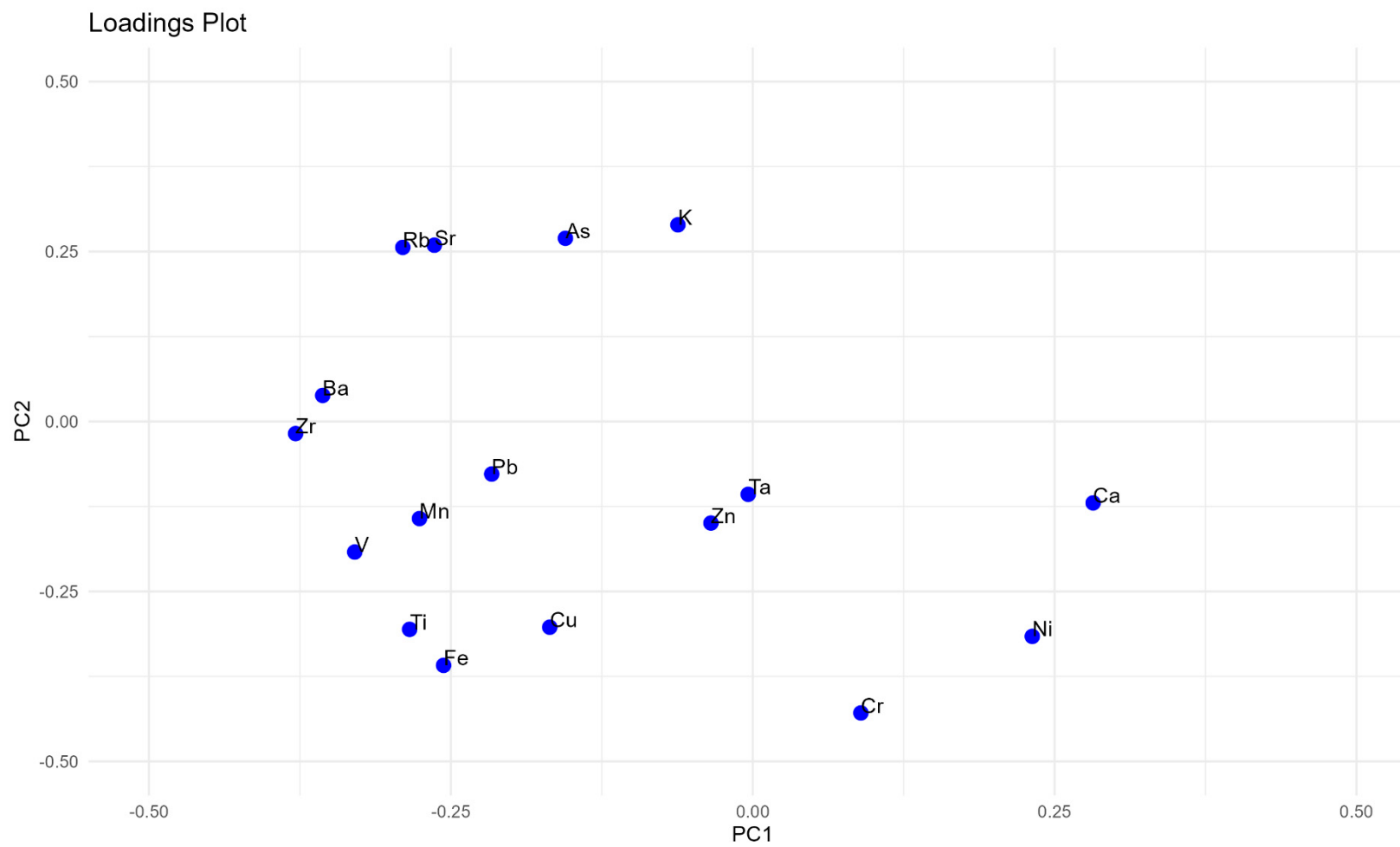


Figure S1: Loadings plot PC1 vs PC2

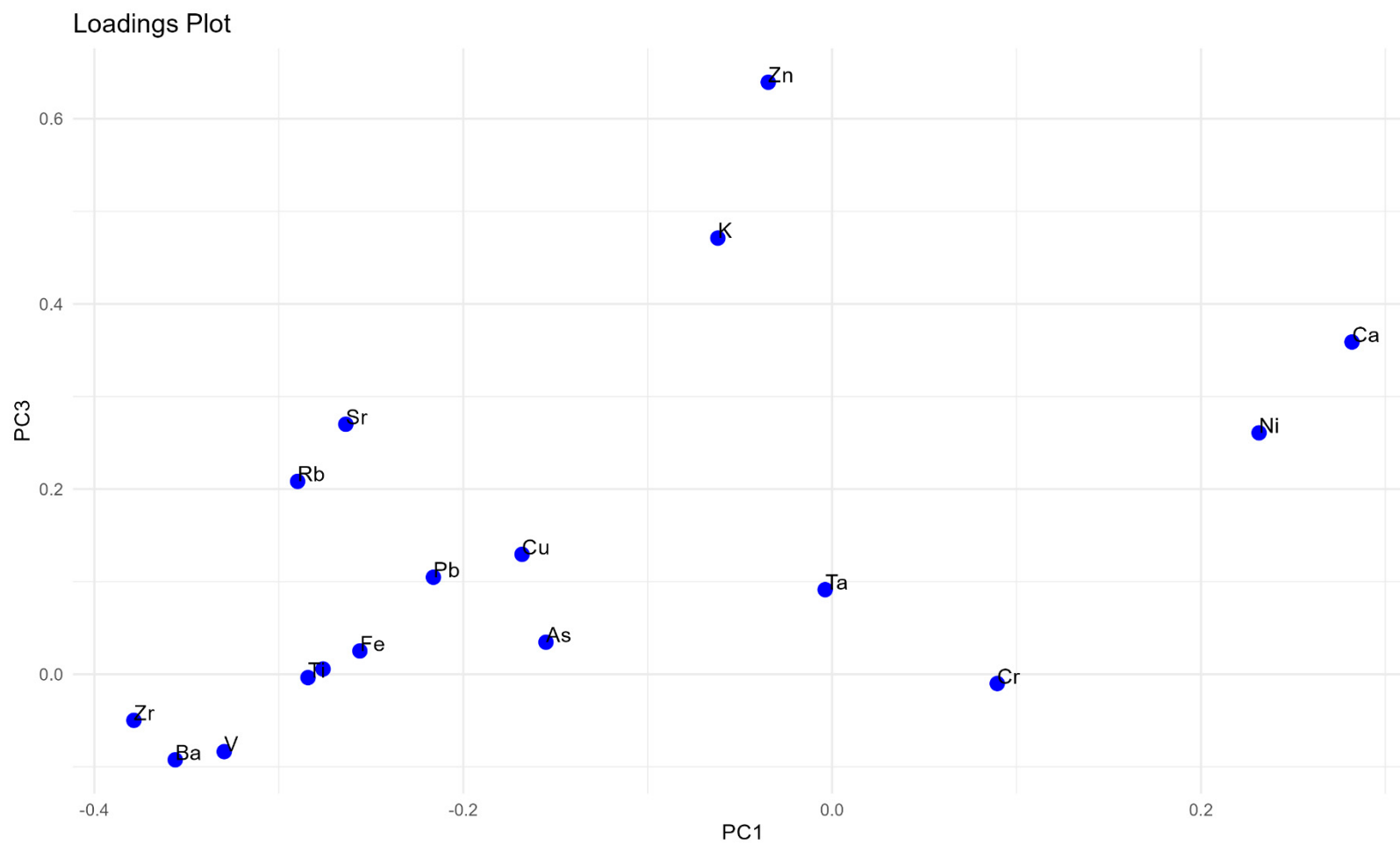


Figure S2: Loadings plot PC1 vs PC3

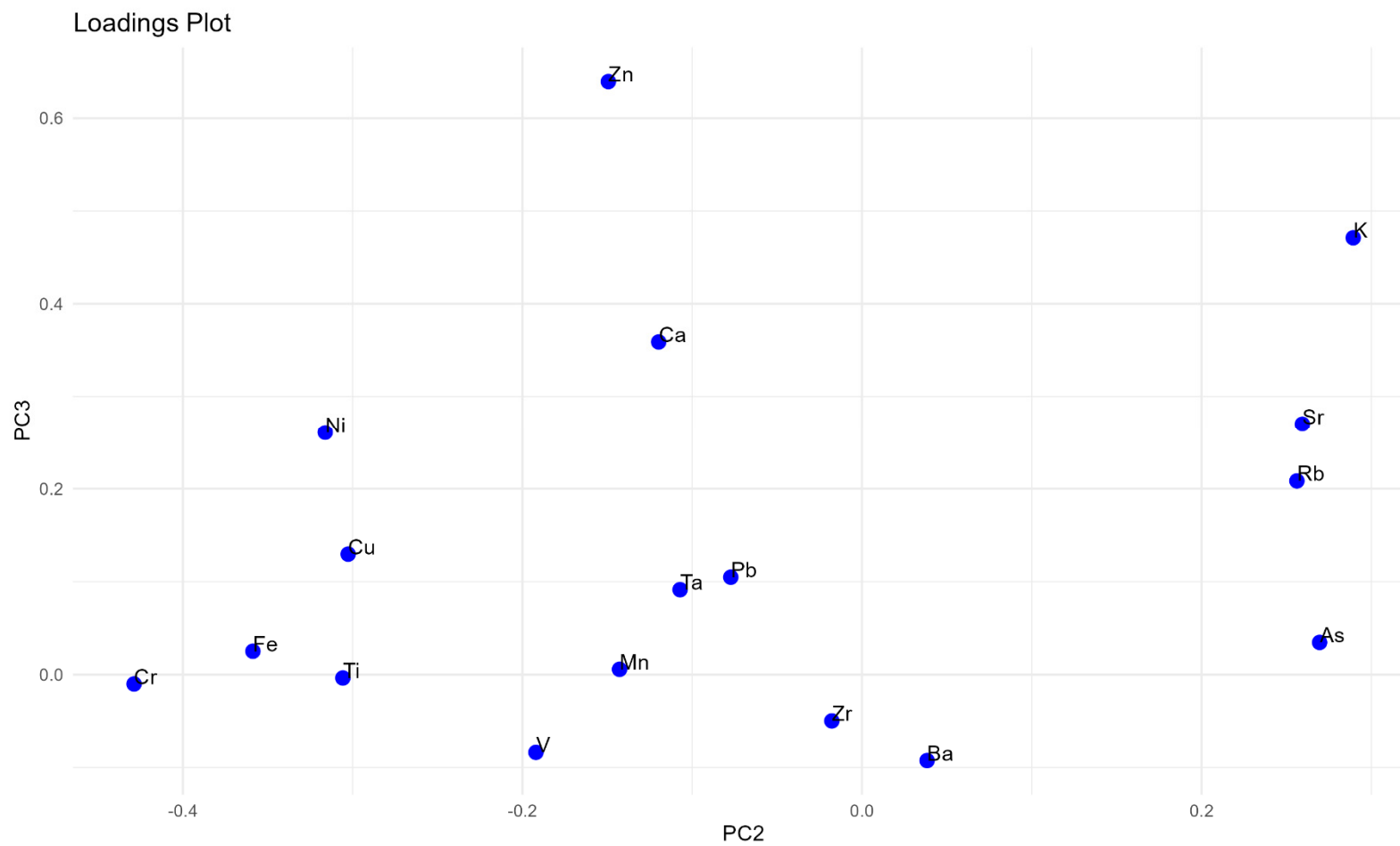


Figure S3: Loadings plot PC2 vs PC3

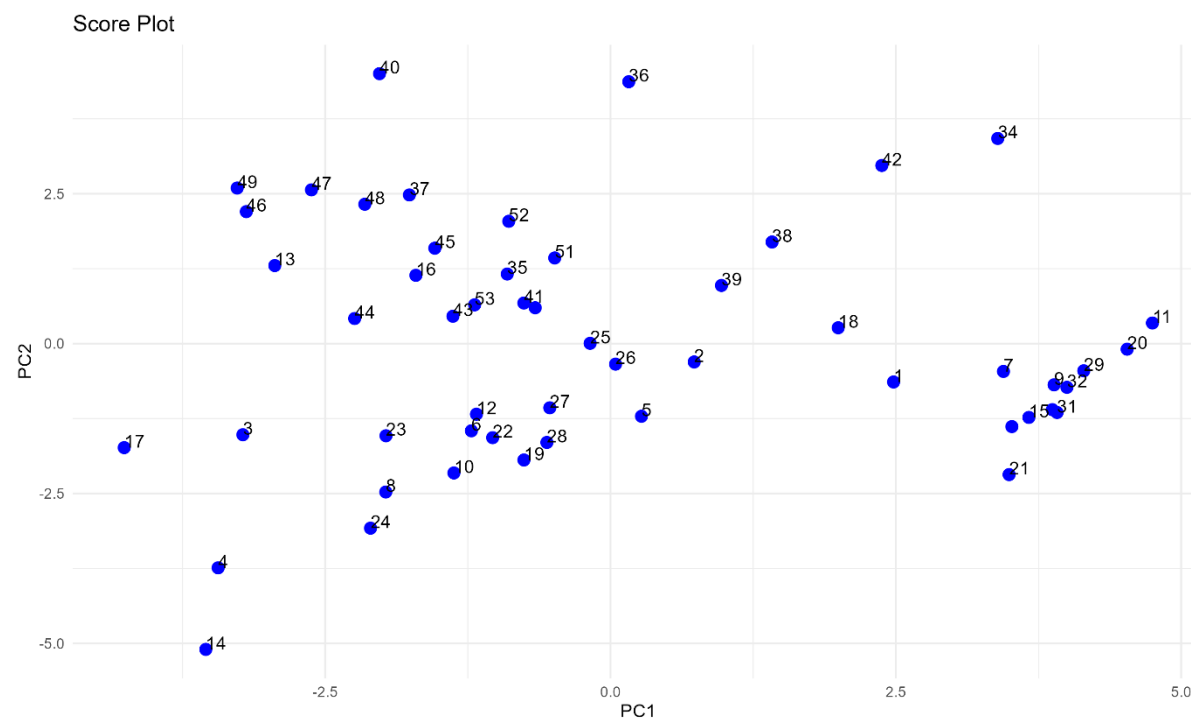


Figure S4: Score Plot of Principal Component 1 (PC1) vs Principal Component 2 (PC2) for Soil Samples

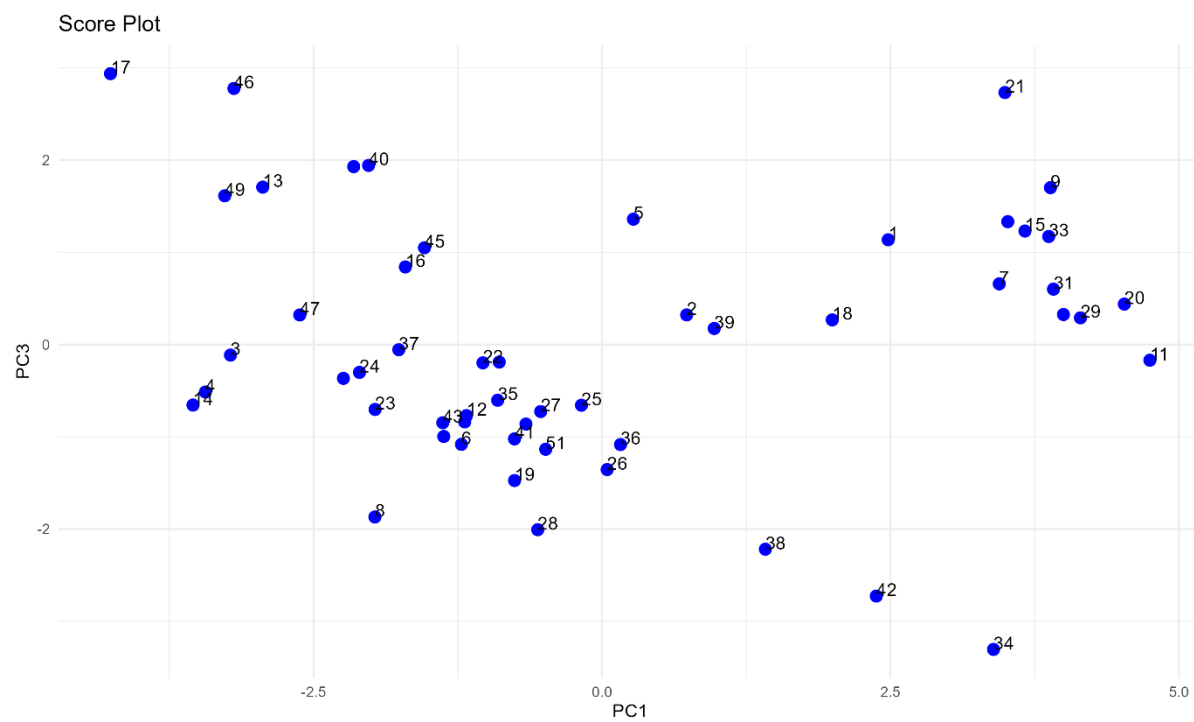


Figure S5: Score Plot of Principal Component 1 (PC1) vs Principal Component 3 (PC3) for Soil Samples

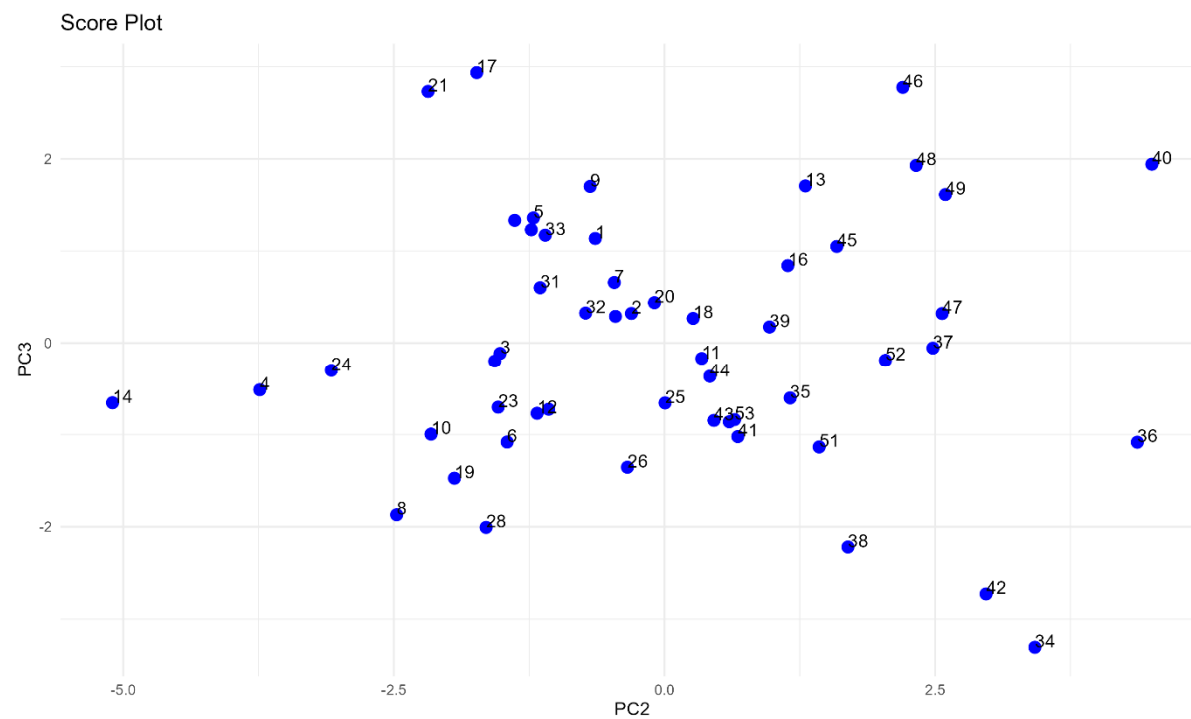


Figure S6: Score Plot of Principal Component 2 (PC2) vs Principal Component 3 (PC3) for Soil Samples

Table S3: Loadings of Elements on Principal Components

Element	PC1 Loading	PC2 Loading	PC3 Loading
Potassium (K)	-0.06195	0.28932	0.47110
Calcium (Ca)	0.28190	-0.11976	0.35886
Titanium (Ti)	-0.28416	-0.30578	-0.00363
Vanadium (V)	-0.32962	-0.19206	-0.08363
Chromium (Cr)	0.08956	-0.42875	-0.01006
Manganese (Mn)	-0.27601	-0.14282	0.00566
Iron (Fe)	-0.25604	-0.35876	0.02511
Nickel (Ni)	0.23151	-0.31616	0.26075
Copper (Cu)	-0.16812	-0.30266	0.12953
Zinc (Zn)	-0.03461	-0.14938	0.63945
Arsenic (As)	-0.15513	0.26952	0.03458
Rubidium (Rb)	-0.28981	0.25615	0.20829
Strontium (Sr)	-0.26368	0.25935	0.27006
Zirconium (Zr)	-0.37858	-0.01778	-0.04982
Barium (Ba)	-0.35615	0.03834	-0.09244
Tantalum (Ta)	-0.00376	-0.10717	0.09132
Lead (Pb)	-0.21617	-0.07729	0.10474