

Human health risk assessment of heavy metals and nitrates associated with oral and dermal groundwater exposure: the Poirino Plateau case study (NW Italy)

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Table S1. Statistical analysis of chemical-physical parameters.

	Mean	Standard deviation
pH	7.94	0.21
EC (μS/cm)	611	242
HCO ₃ (mg/L)	198.99	55.80
SO ₄ (mg/L)	48.99	85.18
NO ₃ (mg/L)	27.54	24.29
Cl (mg/L)	31.22	30.96
F (mg/L)	1.88	1.69
Ca (mg/L)	101.57	45.08
Mg (mg/L)	22.06	10.48
K (mg/L)	5.61	12.34
NH ₄ (mg/L)	0.50	0.45
Na (mg/L)	17.37	10.50
Al (μg/L)	24.45	19.73
CrVI (μg/L)	10.320	11.148
Mn (μg/L)	2.80	2.34
Co (μg/L)	1.708	0.119
Ni (μg/L)	1.29	1.30
Cu (μg/L)	0.40	1.34
Zn (μg/L)	75	357
Cd (μg/L)	<0.058	/
Ba (μg/L)	21.27	13.84
Pb (μg/L)	<0.23	/
HPI	58.02	72.74

Table S2. Non-carcinogenic risk (HQ) for the individual samples and parameters.

ID sample	Parameters	HQ oral			HQ dermal		
		Children	Adults	Workers	Children	Adults	Workers
1	NO ₃	0.782	0.335	0.12	0.01033	0.0035	0.00178
	Cr VI	0.0725	0.0311	0.0111	0.01913	0.00648	0.00329
	NH ₄	0.00316	1.36E-03	4.84E-04	4.2E-05	1.415E-05	7.2E-06
	Ni	0	0	0	0	0	0
	Al	0.00245	1.05E-03	3.76E-04	1.6E-05	5.492E-06	2.8E-06
	Zn	0.00192	8.22E-04	2.94E-04	1.3E-05	4.29E-06	2.2E-06
	Co	0	0	0	0	0	0

	Ba	0.0137	5.89E-03	2.10E-03	0.0013	0.000439 3	0.00022
	F	4.52	1.94E+00	6.92E-01	0.02985	0.01012	0.00513
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	5.3949	2.315	0.82663	0.06077	0.020921 6	0.00996
2	NO ₃	1.18	0.508	0.181	0.01564	0.0053	0.00269
	Cr VI	0.11	0.0475	0.017	0.02925	0.009916	0.00503
	NH ₄	0.00231	9.89E-04	3.53E-04	3E-05	1.032E-05	5.2E-06
	Ni	0	0	0	0	0	0
	Al	0	0	0	0	0	0
	Zn	0	0	0	0	0	0
	Co	0.362	1.55E-01	5.54E-02	0.00239	0.000810 4	0.00041
	Ba	0.00863	3.70E-03	1.32E-03	0.00081	0.000278 5	0.00014
	F	0	0	0	0	0	0
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	1.6616	0.71509	0.25518	0.04787	0.015958 7	0.00498
3	NO ₃	1.98	0.85	0.304	0.02618	0.008875	0.0045
	Cr VI	0	0	0	0	0	0
	NH ₄	0	0	0	0	0	0
	Ni	0	1.10E-03	3.91E-04	0.00042	0.000143	7.3E-05
	Al	0	0	0	0	0	0
	Zn	0.00277	1.19E-03	4.24E-04	1.8E-05	6.197E-06	3.1E-06
	Co	0	0	0	0	0	0
	Ba	0.0112	4.79E-03	1.71E-03	0.00106	0.000357 5	0.00018
	F	0	0	0	0	0	0
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	2.001	0.8574	0.3067	0.02808	0.009688 8	0.00484
4	NO ₃	3.16	1.35	0.483	0.04166	0.01412	0.00072
	Cr VI	0.0469	0.0201	0.00718	0.01238	0.004195	0.00213
	NH ₄	0	0	0	0	0	0
	Ni	0.0131	5.62E-03	2.01E-03	0.00216	0.000732 9	0.00037
	Al	0	0	0	0	0	0
	Zn	0.149	6.40E-02	2.29E-02	0.00099	0.000334 2	0.00017
	Co	0.426	1.83E-01	6.52E-02	0.00281	0.000953 4	0.00048
	Ba	0.0115	4.93E-03	1.76E-03	0.00109	0.000367 7	0.00019
	F	3.94	1.69E+00	6.03E-01	0.02602	0.008819	0.00447

	Mn	0.00073 1	3.13E-04	1.12E-04	6.9E-05	2.335E-05	1.2E-05
	Cu	0	0	0	0	0	0
	HI tot	7.7467	3.32	1.1857	0.08738	0.029791 2	0.01489
5	NO ₃	0.044	0.0189	0.00674	0.00058	0.000197	1E-04
	Cr VI	0	0	0	0	0	0
	NH ₄	0.0265	1.14E-02	4.06E-03	0.00035	0.000118 5	6E-05
	Ni	0.00416	1.78E-03	6.36E-04	0.00069	0.000232 4	0.00012
	Al	0.00067 1	2.88E-04	1.03E-04	4.4E-06	1.502E-06	7.6E-07
	Zn	0	0	0	0	0	0
	Co	0	0	0	0	0	0
	Ba	0.00671	2.88E-03	1.03E-03	0.00063	0.000214 5	0.00011
	F	0	0	0	0	0	0
	Mn	0.00251	1.08E-03	3.84E-04	0.00024	8.026E-05	4.1E-05
	Cu	0	0	0	0	0	0
	HI tot	0.085	0.0363	0.013	0.00252	0.011700 7	0.00045
6	NO ₃	1.36	0.582	0.208	0.01793	0.006078	0.00308
	Cr VI	0.0447	0.0192	0.00685	0.01181	0.004004	0.00203
	NH ₄	0	0	0	0	0	0
	Ni	0.00416	1.78E-03	6.36E-04	0.00069	0.000232 4	0.00012
	Al	0	0	0	0	0	0
	Zn	0	0	0	0	0	0
	Co	0.362	1.55E-01	5.54E-02	0.00239	0.000810 4	0.00041
	Ba	0.0141	6.03E-03	2.15E-03	0.00133	0.000449 5	0.00023
	F	0.309	1.32E-01	4.73E-02	0.00204	0.000691 2	0.00035
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	2.0969	0.8965	0.3204	0.03572	0.011903 6	0.00595
7	NO ₃	0.501	0.215	0.0767	0.00661	0.002241	0.00112
	Cr VI	0.65	0.279	0.0995	0.1716	0.05816	0.02908
	NH ₄	0.0111	0.00477	0.0017	0.00015	4.983E-05	2.5E-05
	Ni	0	0	0	0	0	0
	Al	0	0	0	0	0	0
	Zn	0	0	0	0	0	0
	Co	0.341	0.146	0.0522	0.00225	0.000762 7	0.00038
	Ba	0.00479	0.00205	0.00073	0.00045	0.000153 2	7.7E-05

	F	2.19	0.941	0.336	0.01449	0.00491	0.00246
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	3.6999	1.59139	0.56692	0.19687	0.066955 1	0.03348
8	NO ₃	2.82	1.21	0.431	0.03716	0.0126	0.0063
	Cr VI	0.098	0.042	0.015	0.02588	0.008772	0.00439
	NH ₄	0.00606	2.60E-03	9.28E-04	0.00008	2.713E-05	1.4E-05
	Ni	0.00192	8.22E-04	2.94E-04	0.00032	0.000107 3	5.4E-05
	Al	0	0	0	0	0	0
	Zn	0	0	0	0	0	0
	Co	0.362	1.55E-01	5.54E-02	0.00239	0.000810 4	0.00041
	Ba	0.00479	2.05E-03	7.34E-04	0.00045	0.000153 2	7.7E-05
	F	0	0	0	0	0	0
	Mn	0	0	0	0	0	0
	Cu	0.00417	1.79E-03	6.38E-04	4.8E-05	1.637E-05	8.2E-06
	HI tot	3.3016	1.4093	0.50359	0.06668	0.022891 7	0.01145
9	NO ₃	2.42	1.04	0.371	0.03198	0.01084	0.00542
	Cr VI	0.222	0.095	0.0339	0.05851	0.01983	0.00992
	NH ₄	0.00619	2.65E-03	9.48E-04	8.2E-05	0.000027 7	1.4E-05
	Ni	0.00032	1.37E-04	4.89E-05	5.3E-05	1.788E-05	8.9E-06
	Al	0	0	0	0	0	0
	Zn	0	0	0	0	0	0
	Co	0.405	1.74E-01	6.20E-02	0.00267	0.000905 8	0.00045
	Ba	0.00569	2.44E-03	8.71E-04	0.00054	0.000181 8	9.1E-05
	F	0	0	0	0	0	0
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	3.0577	1.3104	0.4689	0.09339	0.031793 4	0.0159
10	NO ₃	0.615	0.263	0.0941	0.00812	0.002751	0.00138
	Cr VI	0.303	0.13	0.0463	0.07988	0.02708	0.01354
	NH ₄	0.00712	3.05E-03	1.09E-03	9.4E-05	3.185E-05	1.6E-05
	Ni	0.00224	1.55E-01	3.42E-04	0.00037	0.000125 1	6.3E-05
	Al	0	0	0	0	0	0
	Zn	0	0	0	0	0	0
	Co	0.362	1.55E-01	5.54E-02	0.00239	0.000810 4	0.00041
	Ba	0.00095 9	4.11E-04	1.47E-04	9E-05	3.065E-05	1.5E-05
	F	0	0	0	0	0	0

	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	1.2936	0.7064	0.19742	0.09076	0.030918 5	0.01546
11	NO ₃	0.251	0.108	0.0384	0.00332	0.001124	0.00056
	Cr VI	0.831	0.356	0.127	0.2194	0.07437	0.03719
	NH ₄	0	0	0	0	0	0
	Ni	0	0	0	0	0	0
	Al	0	0	0	0	0	0
	Zn	0	0	0	0	0	0
	Co	0.362	0.155	0.0554	0.00239	0.000810 4	0.00041
	Ba	0.00054 3	0.0002.3 3	8.32E-05	5.1E-05	1.737E-05	8.7E-06
	F	2.55	1.09	0.39	0.01683	0.005706	0.00285
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	3.9961	1.7097	0.61134	0.24384	0.082946 5	0.04147
12	NO ₃	1.18	0.507	0.00069	0.0156	0.005288	0.00264
	Cr VI	0.303	0.13	0.0463	0.07988	0.02708	0.01354
	NH ₄	0.00448	1.92E-03	6.86E-04	5.9E-05	2.005E-05	1E-05
	Ni	0	0	0	0	0	0
	Al	0	0	0	0	0	0
	Zn	0	0	0	0	0	0
	Co	0.341	1.46E-01	5.22E-02	0.00225	0.000762 7	0.00038
	Ba	0.00479	2.05E-03	7.34E-04	0.00045	0.000153 2	7.7E-05
	F	0	0	0	0	0	0
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	1.832	0.787	0.10071	0.09782	0.032937 3	0.01647
13	NO ₃	0.381	0.163	0.0583	0.00503	0.001703	0.00085
	Cr VI	0.258	0.111	0.0395	0.06807	0.02307	0.01154
	NH ₄	0	0	0	0	0	0
	Ni	0	0	0	0	0	0
	Al	0	0	0	0	0	0
	Zn	0	0	0	0	0	0
	Co	0.341	1.46E-01	5.22E-02	0.00225	0.000762 7	0.00038
	Ba	0.00339	1.45E-03	5.19E-04	0.00032	0.000108 3	5.4E-05
	F	0	0	0	0	0	0
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	0.986	0.4217	0.15032	0.07584	0.025946 3	0.01297

14	NO ₃	1.02	0.44	0.157	0.01356	0.004597	0.0023
	Cr VI	0	0	0	0	0	0
	NH ₄	0.00402	1.72E-03	0.00062	5.3E-05	1.799E-05	9E-06
	Ni	0	0	0	0	0	0
	Al	0	0	0	0	0	0
	Zn	0.133	5.68E-02	2.03E-02	0.00087	0.000296 5	0.00015
	Co	0	0	0	0	0	0
	Ba	0.00991	4.25E-03	1.52E-03	0.00093	0.000316 7	0.00016
	F	0	0	0	0	0	0
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	1.1747	0.5027	0.1795	0.0155	0.004831 7	0.00242
15	NO ₃	0.637	0.273	0.0975	0.00841	0.00285	0.00143
	Cr VI	0.0149	0.00639	0.00228	0.00394	0.001335	0.00067
	NH ₄	0.00382	1.64E-03	5.85E-04	5E-05	0.000017 1	8.6E-06
	Ni	0	0	0	0	0	0
	Al	0	0	0	0	0	0
	Zn	0	0	0	0	0	0
	Co	0	0	0	0	0	0
	Ba	0.0125	5.34E-03	1.91E-03	0.00118	0.000398 4	0.0002
	F	0	0	0	0	0	0
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	0.6685	0.2862	0.10272	0.01377	0.004982 9	0.00249
16	NO ₃	0.272	0.117	0.0416	0.00359	0.001217	0.00061
	Cr VI	0.262	0.112	0.0401	0.06919	0.02345	0.01173
	NH ₄	0.0054	0.00232	0.00083	7.1E-05	2.418E-05	1.2E-05
	Ni	0	0	0	0	0	0
	Al	0	0	0	0	0	0
	Zn	0.00213	0.00091	0.00033	1.4E-05	0	0
	Co	0.362	0.155	0.0554	0.00239	0.000810 4	0.00041
	Ba	0.00435	0.00186	0.00067	0.00041	0.000138 9	6.9E-05
	F	0	0	0	0	0	0
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	1.1739	0.5002	0.17994	0.0787	0.026896 8	0.01345
17	NO ₃	0.0137	0.00589	0.0021	0.00018	0.000061 5	3.1E-05
	Cr VI	0.0405	0.0174	0.0062	0.01069	0.003623	0.00181
	NH ₄	0.00554	0.00237	0.00085	7.3E-05	2.477E-05	1.2E-05

	Ni	0	0	0	0	0	0
	Al	0	0	0	0	0	0
	Zn	0	0	0	0	0	0
	Co	0.362	0.155	0.0554	0.00239	0.000810 4	0.00041
	Ba	0.0015	0.00064	0.00023	0.00014	4.801E-05	2.4E-05
	F	0	0	0	0	0	0
	Mn	0	0	0	0	0	0
	Cu	0	0	0	0	0	0
	HI tot	0.4218	0.1806	0.06516	0.01475	0.004914 6	0.00246
18	NO ₃	0	0	0	0	0	0
	Cr VI	0.0426	0.0183	0.00652	0.01125	0.003814	0.00191
	NH ₄	0	0	0	0	0	0
	Ni	0	0	0	0	0	0
	Al	0	0	0	0	0	0
	Zn	0.00021 3	9.1E-05	3.3E-05	1.4E-06	4.767E-07	2.4E-07
	Co	0.341	0.146	0.0522	0.00225	0.000762 7	0.00038
	Ba	0.00265	0.00114	0.00041	0.00025	8.479E-05	4.2E-05
	F		0	0	0	0	0
	Mn	0.00059 4	0.00025	9.1E-05	5.6E-06	1.897E-05	9.5E-06
	Cu	0.00726	0.00311	0.00111	8.4E-05	2.848E-05	1.4E-05
	HI tot	0.3952	0.16866	0.05774	0.0149	0.032966 9	0.01648

Table S3. Carcinogenic risk (R) for the individual samples.

ID sample	Parameter	R oral			R dermal		
		Children	Adults	Workers	Children	Adults	Workers
1	Cr VI	1.12E-01	1.60E-02	5.94E-03	6.15E-08	1.042E-07	4.4E-08
2	Cr VI	1.72E-01	2.44E-02	9.09E-03	9.4E-08	1.594E-07	6.74E-08
3	Cr VI	0	0	0	0	0	0
4	Cr VI	7.28E-02	1.03E-02	3.84E-03	3.98E-08	6.742E-08	2.85E-08
5	Cr VI	0	0	0	0	0	0
6	Cr VI	6.95E-02	9.86E-03	3.67E-03	3.8E-08	6.436E-08	2.72E-08
7	Cr VI	1.01E+00	1.43E-01	5.33E-02	5.52E-07	9.347E-07	3.95E-07
8	Cr VI	1.52E-01	2.16E-02	8.04E-03	8.32E-08	1.41E-07	5.96E-08
9	Cr VI	3.44E-01	4.88E-02	1.82E-02	1.88E-07	3.187E-07	1.35E-07
10	Cr VI	4.70E-01	6.67E-02	2.48E-02	2.57E-07	4.352E-07	1.84E-07
11	Cr VI	1.29E+00	1.83E-01	6.81E-02	7.05E-07	1.195E-06	5.05E-07
12	Cr VI	4.70E-01	6.67E-02	2.48E-02	2.57E-07	4.352E-07	1.84E-07
13	Cr VI	4.00E-01	5.68E-02	2.11E-02	2.19E-07	3.708E-07	1.57E-07
14	Cr VI	0	0	0	0	0	0

15	Cr VI	2.32E-02	3.29E-03	1.22E-03	1.27E-08	2.145E-08	9.07E-09
16	Cr VI	4.07E-01	5.78E-02	2.15E-02	2.22E-07	3.769E-07	1.59E-07
17	Cr VI	6.28E-02	8.92E-03	3.32E-03	3.44E-08	5.823E-08	2.46E-08
18	Cr VI	6.61E-02	9.39E-03	3.49E-03	3.62E-08	6.129E-08	2.59E-08