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Element background levels in soils of Liaohe River Plain

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Abstract—Soil background contents of a number of elements of different soil groups, sub-groups and genus on Liaohe River Plain were investigated. It appeared that: the background levels for most elements studied were around the lower limits of the world's averages, variation coefficients of the background content values were from 0.3–0.5 and the element migration coefficients were between 0.9 and 1.0. It was found that the element background contents in soils of eastern and southern parts of the area were generally higher than that of western and northern parts.

Keywords: element background content; trace element; migration coefficient; soil.

INTRODUCTION

During 1983–1985, 1325 samples from 426 soil profiles were collected in an area of $6.3\times10^4 km^2$ in Liaohe River Plain and the contents of 34 elements (including Cu, Zn, Pb, Cd and so on) and the physico-chemical characteristics of soil were measured. In this paper, the regional feature and distribution patterns of the background contents of 34 elements are reported.

NATURAL CONDITIONS AND MAIN SOIL TYPES IN LIAOHE RIVER PLAIN

Liaohe River Plain locates between the eastern and western hills in Liaoning Province, the length from south to north is about 300km, and the width from east to west is about 180km. It slopes from north to south, and from east and west to central part. The elevation in the north part is 50–250m, but it is less than 50m in the south part.

The parent rock is mainly granite in the eastern hills. The extrusive rocks are the main parent rock in the western area. This area has a warm-temperate and semi-humid climate, and a summery green vegetation. The eastern hills are summery green broad-leaf forest, the western hills are xerophyte and bushed prairie, and the central alluvial plain is fertile farmland.

The main soil types of this area are brown earth, cinnamon soil, meadow soil, sandy soil, paddy soil and so on. Brown earth is the zonal soil (41.5% of the total area), and it distributes mainly in the eastern and southwestern parts. It is formed from various parent rocks. The elevation is about 200m. Soil clayization is very evident. The soluable salt and carbonate have

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been leached off, and the pH is neutral. The base saturation degree is 68–85%, organic matter content is 3.25%. In the central alluvial plain, there is a large area of meadow soil (42.4% of the total area). According to the salt content, it can be devided into carbonate meadow soil and saline meadow soil. According to the soil texture it can be devided into sandy, loamy and clay meadow soil genus. Paddy soil accounts for 6.5%. It is formed from meadow soil, swamp soil and meadow brown earth by planting rice. Saline soil accounts for 1.2%, its salt content is above 1%. Aeolian-sandy soil accounts for 5.7%, and mainly distributes in the north-western part. Cinnamon soil accounts for 2.7%, its forming process is clayization, pH is 7.16. The organic matter accumulation is not stronger than brown earth's.

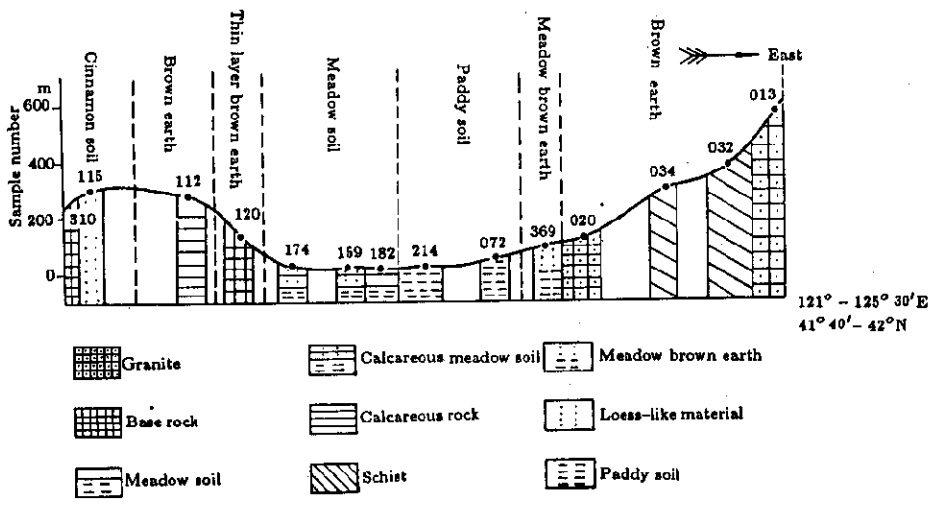

Fig. 1 Soil section in Liaohe River Plain

DISTRIBUTION PATTERN OF ELEMENT BACKGROUND CONTENTS OF DIFFERENT SOIL GROUPS IN LIAOHE RIVER PLAIN

Element background contents of different soil groups

Table 1 Element background contents of different soil groups (average: mg/kg)

Soil groups	Sample number	Elements							
		Cu	Pb	Ni	Zn	Cd	Cr	Hg	As
Brown earth	139	21.8	21.6	25.9	64.8	0.112	53.4	0.036	9.22
Meadow soil	128	20.6	16.7	23.8	52.4	0.078	50.6	0.022	7.25
Cinnamon soil	27	13.0	11.9	20.9	39.7	0.071	47.1	0.015	6.91
Saline soil	16	16.6	16.2	23.7	17.0	0.091	46.0	0.026	6.14
Paddy soil	39	22.0	24.3	28.5	59.2	0.147	62.5	0.053	9.33
Aeolian-sandy soil	21	4.3	6.88	7.0	11.0	0.032	18.3	0.016	4.45
World soil		15–40	15–25	40	50–100	0.5	100–300	0.03–0.1	5–10

It is shown in Table 1 that the distribution patterns of element background contents of different soil groups are as follows:

Cu, Pb, Ni, Cr: paddy soil > brown earth > meadow soil > solonetz > cinnamon soil > sandy soil

Cd, Hg: paddy soil > brown earth > solonetz > meadow soil > cinnamon soil > sandy soil

Zn: brown earth > paddy soil > meadow soil > solonetz > cinnamon soil > sandy soil

As: brown earth > paddy soil > meadow soil > cinnamon soil > solonetz > sandy soil

Brown earth exists under the conditions of warm and humid climate. The vegetative cover is flourishing, and The biological accumulation is significant. Meadow soil and paddy soil locate in lower sites, where surface runoff accumulates. By the longterm cultivation, the agricultural activities can bring some trace elements into soil. In cinnamon soil area, the climate is relatively dry, and the original forest has been demolished. Soil erosion is very serious. All these hinder biological accumulation and rush away plenty of soil fine fractions. So, the metal element contents are lower. Sandy soil contains plenty of quartz, and therefore, the metal elements background level are the lowest.

Element background contents of different soil families

According to the parent rock, parent material and soil texture, the soils in Liaohe River Plain can be devided into 27 soil families. Merge the soil families between which the difference is insignificant in 18 soil families, such as brown earth and thin brown earth from the same

parent, loess brown soil and meadow brown soil. Fuzzy cluster analysis results for 12 elements (Cu, Pb, Ni, Zn, Cd, Cr, Hg, As, pH, organic matter, fractions 0.01–0.001mm and < 0.001mm) contents in 18 soil families are shown in Fig. 2.

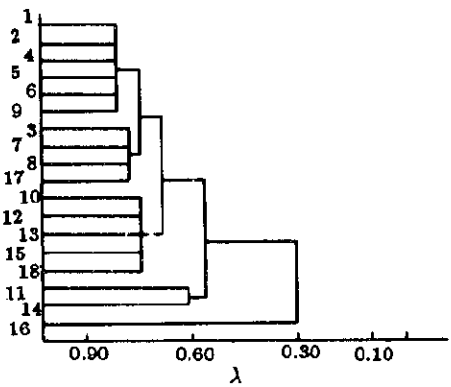

Fig. 2 Fuzzy cluster analysis for soil families

Soil families with: .

(1) the highest element background contents:
calcareous brown earth (X3), clay meadow soil (X8), paddy soil (X17), brown earth from red soil parent matter (X7)

(2) the high element background contents:
brown earth from granite (X1), brown earth from sandy-shale (X2), brown earth from basalt (X4), brown earth from schist (X5), loess brown earth (X6), loamy meadow soil (X9)

(3) the low element background contents:
carbonated loamy meadow soil (X10), cinnamon soil from granite (X12), cinnamon soil from basalt (X13), solonetz (X15), cinnamon soil from red parent matter (X18)

(4) the lowest element background contents:
sandy meadow soil (X11), cinnamon soil from loess (X14), aeolian-sandy soil (X16)

Soil element background contents in different river systems

The main river systems are Taizihe River and Hunhe River. They are all from the eastern hills. Liaohe River consists of East Liaohe River from eastern hills and West Liaohe River from western hills. Because different rivers undergo different parent rocks and soils, the soil texture in brown earth area of eastern part is more clayer, and that in the aeolian-sandy soil area of west part is more sandy. The element background contents of soil in eastern part are higher than those in western part.

Table 2 Element background contents of meadow soils (mg/kg)

Place	Sample number	Elements							
		Cu	Pb	Ni	Zn	Cr	Cd	Hg	As
Liaohe River	37	13.5	12.2	16.7	35.8	35.1	0.057	0.020	6.49
Hunhe River	56	24.0**	21.3**	28.4**	62.4**	60.3**	0.135**	0.034**	8.36*
Taizihe River	6	27.8**	24.8**	34.2**	69.8**	65.5*	0.091*	0.039*	10.73**

*P: 0.001–0.01; **P <0.001

Soil element background contents in different areas

According to the different elements background contents in different soil types, the distribution pattern of the regional soil element background contents are as follows:

hilly area: eastern part > western part

plain area: southern part > northern part

It is concluded from the above mentioned distribution patterns that the factors influencing soil element background contents are as follows:

(1) Parent rock

Parent rock is the material base influencing soil element background contents. Although element contents in different parent rocks migrate and change in the processes of geological cycle and soil forming, the effect of parent rocks on soil is significant. In the hilly area, granite dominates, sedimentary rocks distribute less, and basic rocks are the least. Furthermore, the loess material distributes widely.

Table 3 Element background contents of soils (ppm)

Place	Sample number	Elements			
		Cu	Pb	Ni	Zn
Southern plain	185	21.2±8.3	18.5±6.9	27.5±8.7	54.9±19.4
Northern plain	51	11.2±6.8	11.1±4.4	15.7±8.6	30.9±17.5
Eastern hills	71	23.4±9.4	22.4±5.6	26.4±7.5	73.8±15.00
Western hills	29	13.8±3.9	12.4±3.3	22.1±5.6	41.2±12.8

	Elements			
Southern plain	Cd	Cr	Hg	As
Northern plain	0.091±0.049	57.5±20.3	0.029±0.016	8.36±2.98
Eastern hills	0.046±0.023	33.1±20.0	0.019±0.014	6.37±2.61
Western hills	0.125±0.072	57±17.2	0.04±0.02	8.95±2.54
	0.066±0.024	48.0±1.5	0.019±0.013	7.03±1.65

Table 4 indicates that the contents of Cd, Pb, Cu, Zn, Hg, As are highest in calcareous rock, lowest in granite, and medium in loess parent material. Ni, Cr contents are highest in base rock, lowest in granite. In the tertiary red clay, the Pb, Ni, Zn are richer but buried deeply. So their effect on soil is not very significant.

(2) Texture

It is known that the contents of heavy metals in different granulometric composition are as follows: clay > fine silt > middle silt > sandy fraction. In this area, the granulometric composition of loess parent material becomes finer from northwest to southeast. In west part. it's mainly coarse silt, called sandy loess. In east part, it's mainly middle fine, called clayey loess (Fig. 3).

There is a significant difference between the contents of brown earth and cinnamon soil developed from these two kinds of loess (Cd, Hg: P 0.1–0.2; other 6 elements: $P < 0.001$). In the western part of this area, there is a large area of sandy meadow and aeolian sandy soil. The clay fraction content is 7.78% and coarse silt content is 5.11%, which is lower than any others. The element contents in this area are also lower than others.

Table 4 Element contents of burozem soil developed on different parent materials (mg/kg)

Parent rock	Sample number	Elements							
		Cu	Pb	Ni	Zn	Cd	Cr	Hg	As
Granite	40	24.3*	19.07*	21.30*	67.9*	0.11	50.4	0.034	7.48
Sandy shale	3	19.0	20.2	24.8*	61.7*	0.10	41.6	0.03	7.37
Calcareous rock	18	27.4	29.2	32.1	79.5	0.19	63.5	0.046	11.9
Basic rock	10	19.9	18.4*	34.63*	60.6	0.07	66.55	0.028	8.47
Schist	9	22.6	24.2	25.4*	71.75	0.109	54.7	0.033	9.25
Loess material	58	22.4	20.4	26.8	57.7*	0.12	55.8	0.038	9.9
Red clay	2	26.0*	31.2	36.95*	89.0	0.067	49.65	0.020	7.46

*show the significant difference to calcareous brown earth

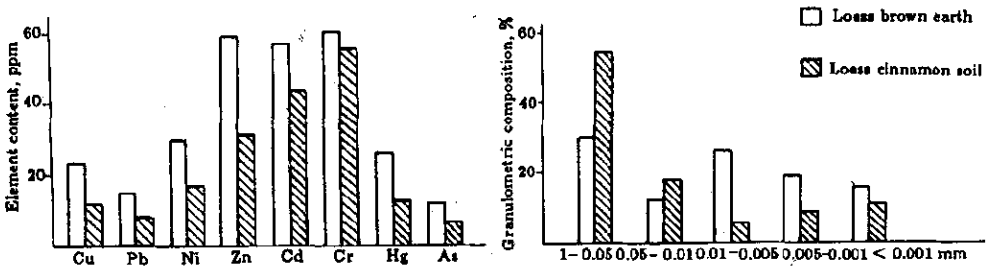

Fig 3 Granulometric compositions and element background contents of brown earth and cinnamon soils

Table 5 Element background contents of meadow soils with different texture

Soil genus	Sample number	Elements							
		Cu	Pb	Ni	Zn	Cd	Cr	Hg	As
Sandy meadow soil	14	13.7	13.3	16.3	30.0	0.056	39.1	0.0145	4.52
Loamy meadow soil	50	20.1	18.0	25.9	58.7	0.095	54.5	0.0275	7.73
Clayey meadow soil	15	33.7	24.8	35.2	78.6	0.140	69.9	0.0318	10.6

Soil genus	Granulometric composition		Organic matter,
	0.01-0.001mm, %	<0.001mm, %	%
Sandy meadow soil	4.03	2.60	1.05
Loamy meadow soil	22.18	6.47	1.84
Clayey meadow soil	53.75	8.69	2.31

THE REGIONAL FEATURES OF SOIL ELEMENT BACKGROUND CONTENTS IN LIAOHE RIVER PLAIN

The soil element background contents in Liaohe River Plain are the weighted averages by the percentage of different soil group areas (Table 6).

Table 6 Element background contents of soils in Liaohe River Plain (mg/kg)

Place	Sample number	Elements								
		Cu	Pb	Ni	Zn	Cd	Cr	Hg	As	BaP, ppb
Liaohe River Plain	426	20.8	19.9	24.6	55.4	0.11	52.1	0.034	8.17	4.08
Shenyang City	107	24.6	22.2	27.9	59.8	0.16	57.6	0.050	8.79	50.7

Table 7 Soil background contents of 28 elements in Liaohe River Plain (mg/kg)

Element	Sample number	Whole range	Background values AM	SD	CV	Earth crust abundance, D	A/D	World soil content
Macroelement, 100%								
Na	53	0.01–1.92	1.03	0.242	0.235	2.5	0.412	0.8
Ca	53	0.01–2.17	0.94	0.696	0.740	3.6	0.261	1.37
Mg	53	0.13–1.38	0.545	0.223	0.409	1.87	0.291	0.63
Fe	53	0.54–4.96	2.44	0.31	0.332	4.65	0.525	3.8
Microelement								
Sr	53	16–382	121.2	45.3	0.374	375	0.323	300
Ba	53	95–787	457.8	84.6	0.184	425	1.077	500
TiO_2 %	53	0.19–1.39	0.702	0.23	0.328	0.45	1.56	0.46
Cr	53	4.91–140.2	57.6	29.7	0.515	100	0.576	100–300
Mn	53	86–1370	423.6	171.9	0.406	950	0.446	850
Ni	53	3–67.6	28.8	14.0	0.487	75	0.384	40
Cu	53	2.4–70.4	23.2	13.0	0.599	55	0.42	15–40
Zn	53	6.2–115	54.2	20.4	0.376	70	0.774	50–100
Cd	53	0.016–0.41	0.078	0.027	0.339	0.2	0.39	0.5
Hg	53	0.002–0.097	0.025	0.0128	0.512	0.083	0.301	0.03–0.1
Pb	53	3.4–102.7	18.8	6.30	0.335	12.5	1.50	15–25
As	53	1.62–19.79	8.35	2.00	0.240	1.8	4.63	5–10
Se	53	0.046–1.94	0.185	0.066	0.357	0.05	3.7	0.2
V	53	14–253	80.7	30.1	0.372	265	0.305	100

Table 7 (continued)

Rare earth element								
La	40	12.4–74.8	34.1	8.38	0.246	30	1.137	40
Ce	40	24.1–105	71.9	15.7	0.219	60	1.197	50
Nd	40	14.3–62.7	36.2	10.7	0.295	88	1.293	35
Sm	40	1.96–8.30	5.73	1.38	0.241	6.0	0.955	4.5
Eu	40	0.469–1.85	1.16	0.29	0.25	1.2	0.967	1
Tb	40	0.313–1.23	0.776	0.200	0.258	0.9	0.862	0.7
Yb	40	0.733–2.73	2.51	0.472	0.188	3.0	0.837	3
Lu	40	0.152–0.558	0.427	0.082	0.192	0.5	0.854	0.4
U	40	0.469–4.27	2.34	0.664	0.284	2.7	0.867	2
Th	40	3.15–15.7	10.7	8.93	0.274	9.6	1.115	9

The results of the regional soil elements background contents in Liaohe River Plain in comparison with the earth crust abundance, and world soil content are listed in Table 7.

Several features could be noted from this comparison

(1) Most of element contents have lower contents, at the lower end of soil element contents range in the world. However, Ti content is higher, and Na and Ba contents are approximately equal to the average of the world. Elements with slightly lower contents are: Cu, Pb, Ni, As, Mn, V, Ca, Mg. Elements with lower contents are Fe, Sr, Cr, Zn, Cd, Hg, Se. In this area, the contents of alkali and alkaline-earth metals depend on different soil groups, and the ratio to the earth crust abundance is lower than 1. It is shown that leaching is the feature of this humid area. Sr is a strongly migrating element, its content in this area is 121.2mg/kg, much lower than that in arid soil (Xinjiang: 380mg/kg), but higher than that in Xiangjiang River valley soil (57mg/kg), and that in Huanan soil (28.0mg/kg). The average content of Se is 0.185mg/kg, lower than the average content of the world. The Se content in brown earth is 0.135mg/kg, and 0.152mg/kg in cinnamon soil. Not only the total Se is low, the amount of available Se is also low, therefore, this area is a endemic disease area. The Se content is higher than that in Northeastern China (0.108mg/kg). The sequence of soil element contents of the world is:Cr > Zn > Ni > Pb > As > Cd > Hg. In Liaohe River plain, the sequence is similar, except Zn > Cr, because the parent rocks in this area are granite and loess. One of the reasons resulting

in low element background contents in this area is the natural geography conditions, such as low temperature and freezing which cause weak weathering of rocks and minerals. Soil texture is also coarse. Granulometric composition average: > 0.01mm 64% , 0.01–0.001mm 27%, < 0.001mm 9.0%. Clay fraction content in paddy soil is 12.43%, 4.20% in brown earth and 11.10% in cinnamon soil.

(2) The variation coefficients for the background contents are 30–50%. For rare earth element, it is 20–30%. It is largest for Ca, about 74%, because of the zonal difference of soil forming process. In Liaohe River plain, the parent material is mainly alluvium. It is more or less homogeneous. So the variation coefficients are small.

Table 8 Variation coefficients of element contents in different soil groups

Soil groups	Cu	Pb	Ni	Zn	Cd	Cr	Hg	As
Brown earth	0.41	0.49	0.33	0.29	0.59	0.39	0.48	0.27
Meadow soil	0.58	0.47	0.42	0.47	0.67	0.46	0.64	0.39
Cinnamon soil	0.34	0.42	0.38	0.29	0.34	0.42	0.49	0.26
Saline-alkali soil	0.45	0.39	0.41	0.51	0.53	0.45	0.54	0.55
Sandy soil	0.54	0.33	0.43	0.59	0.53	0.42	0.62	0.37
Paddy soil	0.15	0.14	0.16	0.28	0.35	0.25	0.49	0.32

Table 9 Variation coefficients of element contents in different sub-groups of brown earth

Sub-groups	Cu	Pb	Ni	Zn	Cd	Cr	Hg	As
Thin brown earth	0.563	0.536	0.378	0.355	0.678	0.413	0.491	0.330
Brown earth	0.396	0.496	0.37	0.244	0.532	0.418	0.506	0.265
Meadow Brown earth	0.32	0.495	0.18	0.245	0.486	0.323	0.413	0.223

(3) The migrating coefficients in this area are between 0.9–1.0. This shows the clay fraction is not destroyed in the process of neutral leaching clayization occurs in the illuvial horizon of brown earth and cinnamon soil. The average contents of Ni, Cr and As are higher than those

in the eluvial horizons, but the difference is insignificant statistically ($P > 0.05$). Only in the illuvial horizon of brown earth and meadow brown earth developed on loess, and the same horizon of cinnamon soil developed on granite, the process of Ni illuviation are significant. In most other soils, no significant difference exist. The migrating coefficient of Ca is higher, specially in the B horizon of cinnamon soil, it is up to 2.12.

THE RELATIONSHIPS AMONG ELEMENTS IN LIAOHE RIVER PLAIN

Table 10 lists the relative matrix of 53 main profiles, 18 elements, 22 analysing items according to different soil genus, rock and total area. " + " or " −− " means positive or negative relation ($0.05 > P > 0.01$); " ++ " or " −− " means significant relation ($0.01 > P > 0.001$); " +++ " or " − − − " means extremely significant relation ($P < 0.001$) ; " 0 " means no relation. In Table 10, there are several relative groups:

(1) Among Cu, Zn, Ni, V, Ti, Se, Fe, Mn, Cr, most are significant positive relation.

(2) Na, Sr, Ba, Ca appear positive relation, but to Fe, Mn, Cu, Zn, no relation exists.

(3) Pb, Cd, Hg, As are thiophil elements, the relations among them are closely.

(4) Organic matter and Ti, Cu, Ni, Zn, Cd, Cr, Se, V, Fe, Mn, Mg, the relations are close.

The relationship among above elements are coincident with the elements composition and migrating features of granite brown earth and loessal brown earth. According to the relationships among elements, the multivariant regression of 18 soil genus, 12 variables (Cu, Pb, Ni, Zn, Cd, Cr, Hg, As, pH, organic matter, 0.01–0.001mm granulometric composition percent and <0.001mm granulometric composition percent) is made. The multivariant regression equation and the complex relative coefficients are as follows. According to these, the element contents can be estimated each other.

Table 10 Correlation coefficient among element contents of different soil groups

	>0.01	0.01–0.001	<0.001	Cu	Pb
>0.01		−−−	−−−		−−−
01–0.001	−0.8715				+++
<0.001	−0.5565	0.0816		−	
Cu	0.0712	0.0857	−0.3102		
Pb	−0.5196	0.6386	−0.0229	0.2463	
Ni	0.0632	0.1218	−0.3516	0.9741	0.2775
Zn	−0.2472	0.5128	−0.3804	0.6878	0.6606
Cd	−0.0114	0.2150	−0.3496	0.5270	0.6187
Cr	0.0752	0.0824	−0.3275	0.9585	0.2377
Hg	−0.3850	0.5249	−0.1089	0.1459	0.4679
As	−0.5732	0.7828	−0.1562	0.2398	0.6869
Se	−0.0347	0.1143	−0.0998	0.4713	−0.4011
Ba	0.1736	−0.1747	−0.0852	−0.2147	−0.2500
Sr	0.02951	−0.2982	−0.1428	0.0541	−0.2029
V	0.0090	0.2022	−0.3670	0.8966	0.3275
Mn	0.1574	0.1501	−0.5934	0.6283	0.4633
Fe	−0.0637	0.3326	−0.4521	0.7257	0.4876
Mg	0.2900	−0.0387	−0.5517	0.8838	0.2014
Na	0.1707	−0.2084	−0.0645	−0.1107	−0.2716
Ca	0.1303	−0.1360	−0.0461	−0.0962	0.0484
Ti	0.9906	0.1032	−0.3940	0.9277	0.3146
Organic matter	0.2990	−0.1566	−0.3608	0.7127	0.2267

Table 10 (continued)

	Ni	Zn	Cd	Cr	Hg	As
>0.01					−−	−−−
0.01-0.001		+++			+++	+++
<0.001	−	−−	−	−		
Cu	+++	+++	+++	+++		
Pb	+	+++	+++		+++	+++
Ni		+++	+++	+++		+
Zn	0.6918		+++	+++	+++	+++
Cd	0.6095	0.7333		+++	+	++
Cr	0.9494	0.7039	0.5341			+
Hg	0.1452	0.4656	0.2749	0.1941		+++
As	0.2934	0.6674	0.4202	0.2767	0.7284	
Se	0.5008	0.6123	0.6648	0.4522	0.3101	0.4172
Ba	−0.2584	−0.4578	−0.4230	−0.2423	−0.4174	−0.4147
Sr	0.0051	−0.0374	−0.0374	−0.0078	−0.2494	−0.4858
V	0.9269	0.6924	0.6924	0.8686	0.2564	0.3662
Mn	0.8710	0.7197	0.7197	0.8213	0.2322	0.4640
Fe	0.9304	0.6463	0.6463	0.9073	0.2973	0.4973
Mg	0.8723	0.5502	0.4926	0.8391	0.1303	0.1366
Na	−0.1931	−0.2323	−0.3597	−0.0876	−0.3736	−0.4672
Ca	−0.0752	−0.3217	0.1046	−0.1426	−0.2677	−0.3090
Ti	0.9532	0.7269	0.6045	0.9537	0.2133	0.3054
Organic matter	0.6689	0.6357	0.5698	0.7465	0.1582	0.0152

$\overset{+++}{---}$ $P < 0.001$ $\overset{++}{--}$ $0.01 > P > 0.001$ $\pm 0.05 > P > 0.01$

Table 10 (Continued)

	Se	Ba	Sr	V	Mn
>0.01			+		
0.01−0.001			−		
<0.001				−−	−−−
Cu	+++			+++	+++
Pb	++			+	+++
Ni	+++			+++	+++
Zn	+++	−−−		+++	+++
Cd	+++	−		+++	+++
Cr	+++			+++	+++
Hg	+	−−			
As	++	−−	−− −	++	+++
Se		−−−	−	+++	+++
Ba	−0.5826		+++	−−	
Sr	−0.2992	0.6833			
V	0.5824	−0.4382	−0.0651		+++
Mn	0.5570	−0.1972	−0.0235	0.5219	
Fe	0.5304	−0.2115	−0.0501	0.8736	0.9253
Mg	0.3139	0.0446	0.3816	0.7807	0.8350
Na	−0.5236	0.7376	0.6065	−0.3631	−0.2173
Ca	−0.2136	0.5946	0.7999	−0.1051	−0.0190
Ti	0.4047	−0.3053	−0.3053	0.8710	0.8532
Organic matter	−0.4643	−0.2311	0.0363	0.6393	0.6068

Table 10 (Continued)

	Fe	Mg	Na	Ca	Ti	Organic matter
>0.01		+				+
0.01–0.001	+					
<0.001	−−−	−−−			−−	−−
Cn	+++	+++			+++	+++
Pb	+++				+	
Ni	+++	+++			+++	+++
Zn	+++	+++		−	+++	+++
Cd	+++	+++	−−		+++	+++
Cr	+++	+++			+++	+++
Hg	+		−−			
As	+++		−−−	−	−	
Se	+++	+	−−−		++	+++
Ba			+++	+++	−	
Sr		+	+++	+++	−	
V	+++	+++	−		+++	+++
Mn	+++	+++			+++	+++
Fe		−−−			+++	+++
Mg	−0.8415				+++	+++
Na	0.1478	0.0449				
Ca	−0.1159	0.2101	0.2479			
Ti	0.9019	0.8406	−0.1217	0.1813		+++
Organic matter	0.6795	0.6429	0.0025	−0.2008	0.7351	

$$y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 +, \ldots, a_{11}x_{11}$$

Cu = y
$a_0 = -4.720$
$a_1 = 0.719$ Pb
$a_2 = -0.164$ Ni
$a_3 = 0.203$ Zn
$a_4 = -84.534$ Cd
$a_5 = 0.138$ Cr
$a_6 = -1.707$ Hg
$a_7 = -0.229$ As
$a_8 = 0.463$ pH
$a_9 = -0.136$organic matter
$a_{10} = 0.194(0.01 - 0.001)$
$a_{11} = 0.0.10(< 0.001)$
$R = 0.794$

Pb = y
$a_0 = 26.862$
$a_1 = 0.331$ Cu
$a_2 = 0.506$ Ni
$a_3 = 0.029$ Zn
$a_4 = 120.087$ Cd
$a_5 = -0.170$ Cr
$a_6 = -10.306$ Hg
$a_7 = 0.048$ As
$a_8 = -3.465$ pH
$a_9 = -1.806$organic matter
$a_{10} = -0.175(0.01 - 0.001)$
$a_{11} = -0.085(< 0.001)$
$R = 0.985$

Ni = y
$a_0 = -37.814$
$a_1 = -0.120$ Cu
$a_2 = 0.806$ Pb
$a_3 = -0.060$ Zn
$a_4 = 131.621$ Cd
$a_5 = 0.308$ Cr
$a_6 = 14.527$ Hg
$a_7 = 0.537$ As
$a_8 = 4.949$ pH
$a_9 = 3.136$ organic matter
$a_{10} = 0.206(0.01 - 0.001)$
$a_{11} = 0.075(< 0.001)$
$R = 0.979$

Zn = y
$a_0 = -24.908$
$a_1 = 1.198$ Cu
$a_2 = 0.489$ Pb
$a_3 = -0.489$ Ni
$a_4 = 43.668$ Cd
$a_5 = 0.290$ Cr
$a_6 = 29.172$ Hg
$a_7 = 1.748$ As
$a_8 = 2.433$ pH
$a_9 = 7.032$ organic matter
$a_{10} = 0.042(0.01 - 0.001)$
$a_{11} = 0.186(< 0.001)$
$R = 0.9766$

Cd = y
$a_0 = -0.195$
$a_1 = -0.002$ Cu
$a_2 = 0.006$ Pb
$a_3 = -0.004$ Ni
$a_4 = -0.001$ Zn
$a_5 = 0.0016$ Cr
$a_6 = 0.075$ Hg
$a_7 = 0.0004$ As
$a_8 = 0.024$ pH
$a_9 = 0.016$ organic matter
$a_{10} = 0.001(0.01 - 0.001)$
$a_{11} = 0.0006(< 0.001)$
$R = 0.9827$

Cr = y
$a_0 = 56.001$
$a_1 = 0.579$ Cu
$a_2 = -1.549$ Pb
$a_3 = 1.760$ Ni
$a_4 = 0.206$ Zn
$a_5 = 288.477$ Zn
$a_6 = -16.679$ Hg
$a_7 = -0.861$ As
$a_8 = -6.142$ pH
$a_9 = -5.917$ organic matter
$a_{10} = -0.366(0.01 - 0.001)$
$a_{11} = -0.096(< 0.001)$
$R = 0.9650$

$Hg = y$	$As = y$
$a_0 = 1.229$	$a_0 = 3.229$
$a_1 = 0.001$ Cu	$a_1 = -0.058$ Cu
$a_2 = -0.022$ Pb	$a_2 = 0.026$ Pb
$a_3 = 0.019$ Ni	$a_3 = 0.187$ Ni
$a_4 - 0.004$ Zn	$a_4 = 0.075$ Zn
$a_5 = 2.970$ Cd	$a_5 = 4.176$ Cd
$a_6 = -0.004$ Cr	$a_6 = -0.052$ Cr
$a_7 = -0.011$ As	$a_7 = -2.786$ Hg
$a_8 = -0.167$ pH	$a_8 = 0.033$ pH
$a_9 = -0.099$ organic matter	$a_9 = -0.640$ organic matter
$a_{10} = -0.005(0.01 - 0.001)$	$a_{10} = 0.032(0.01 - 0.001)$
$a_{11} = -0.002(< 0.001)$	$a_{11} = -0.056(< 0.001)$
$R = 0.7467$	$R = 0.9159$

Considering to the 12 items multivariant regression, the relationship between dependent variables and arguments is too complex, the graduate regression is used and eliminate the factors influencing gently, calculate 8 elements principal component analysis, the results are as follows:

$$\mathrm{Hg} = -0.015 - 0.003\mathrm{Cu} - 0.002\mathrm{Pb} - 0.001\mathrm{Ni} + 0.003\mathrm{Zn} - 0.238\mathrm{Cd} + 0.003\mathrm{Cr} - 0.008\mathrm{As} \qquad R = 0.3429$$

$$\mathrm{As} = 2.081 + 0.113\mathrm{Cu} + 0.152\mathrm{Ni} \qquad R = 0.8800$$

$$\mathrm{Cr} = 11.1049 + 1.097\mathrm{Ni} + 11.8934\mathrm{Cd} \qquad R = 0.9301$$

$$\mathrm{Zn} = 4.496 + 1.508\mathrm{Cu} + 1.049\mathrm{pb} \qquad R = 0.9363$$

$$\mathrm{Ni} = -2.188 + 0.301\mathrm{Cr} + 1.46\mathrm{As} \qquad R = 0.9258$$

$$\mathrm{Pb} = 2.541 + 0.435\mathrm{Cu} + 77.736\mathrm{Cd} \qquad R = 0.9587$$

$$\mathrm{Cu} = 0.183 + 0.362\mathrm{Zn} \qquad R = 0.9229$$

The regression equation of each element to soil pH, organic matter and texture (0.01-0.001mm, <0.001mm granulometric composition content) are as follows:

$$\mathrm{Cu} = 15.029 - 1.288\mathrm{pH} + 2.069\text{organic matter} + 0.389(0.01 - 0.001) - 0.062(< 0.001)$$
$$(0.01 - 0.001) - 0.064 \qquad R = 0.9046$$

$$\mathrm{Pb} = 19.7325 - 1.956\mathrm{pH} + 2.566\text{organic matter} + 0.279(0.01 - 0.001) - 0.064(< 0.001) \qquad R = 0.8857$$

$$\mathrm{Ni} = 19.752 + 4.397\mathrm{pH} + 3.297\text{organic matter} + 0.342(0.01 - 0.001) - 0.078(< 0.001) \qquad R = 0.8747$$

$$\mathrm{Zn} = 2.108 + 9.929\mathrm{pH} + 0.754\text{organic matter} + 0.048(0.01 - 0.001) + 0.048(< 0.001mm) \qquad R = 0.9192$$

$$\mathrm{Cd} = 0.038 - 6.111\mathrm{pH} + 0.019\text{organic matter} + 0.002(0.01 - 0.001) + 0.001(< 0.001) \qquad R = 0.8603$$

$$Cr = 6.339 + 2.412pH + 4.449\text{organic matter} + 0.657(0.01 - 0.001) + 0.220(< 0.001)$$

$$R = 0.833$$

$$Hg = 0.629 - 0.085pH - 0.014\text{organic matter} + 0.00018(0.01 - 0.001) + 0.0012(< 0.001)$$

$$R = 0.3756$$

$$As - 0.6539 + 0.804pH + 0.559\text{organic matter} + 0.111(0.01 - 0.001) - 0.074(< 0.001)$$

$$R = 0.8538$$

CONCLUSION

The sequence of soil element background contents in different soil groups in Liaohe River Plain are as follows: paddy soil > brown earth > meadow soil > solonetz > cinnamon soil > aeolian-sandy soil. The factors influencing soil background contents are the difference of parent rock in hilly area and the granularity varies in plain area. Among the 18 soil genus in this area, the element background contents are higher in calcareous brown earth, clayey meadow soil, paddy soil and red parent matter brown earth. Because of the difference of soil background contents in different soil groups, the distribution pattern in this region is: east and south part > west and north part. The background contents of soil elements in Liaohe River Plain are mostly at the lower end of the contents range of the world. In the northeastern China, the sequence of soil background contents is Shenyang City > Liaohe River Plain > Songnen Plain.

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