Analysis on the Sources of Soil Heavy Metal Cadmium Pollution in Hubei Province

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Abstract. In this paper, researches on the sourcs of cadmum in soil of Hubei province were concucted. Results of soil profile analysis showed that the accumulation of Cd to a certain extent in the surface soil was mainly caused by the alluvial diluvium of the fourth system and human factors. Correlation analysis revealed the correlation between Cd and other heavy metal. Results of factor and cluster analysis both presented anthropogenic sources, including traffic, industrial and agricultural activities.

Keywords: Cadmum, heavy metal, source analysis, anthropogenic sources.

1. Introduction

Soil is an indispensable part of ecosystem and important medium for the transformation of matter and energy in environmental system. Soil pollution plays an important role in the three-dimensional pollution of agricultural system. When the heavy metal concentration in soil exceeds a certain level, it can bring many environmental problems. Among them, cadmium (Cd) is one of the "five toxic" elements known by the public, which has the characteristics of high mobility, long decomposition cycle and high toxicity [1].

The sources of heavy metal pollution in soil are complex and influenced by both natural soil formation and human activities [2]. The soil formed by natural weathering of bedrock retains some characteristics of bedrock composition, and the soil has a strong inheritance to the geochemical characteristics of the parent material. Human activities are also important sources of soil heavy metals. they can be divided into industrial, domestic and agricultural sources. Heavy metals from different sources enter the soil in different ways, and eventually cause soil heavy metal pollution.

2. Materials and methods

This study focused on Jianghan plain area in Hubei Province, which is a typical plain landform. The soil types are mainly moisture soil and paddy soil. Five-point sampling method was used for sampling, and each sample was composed of 5 sub-samples within the range of 20 ~ 50m. A total of 70130 samples were collected. The content of heavy metals in soil was determined by inductively coupled plasma mass spectrometry (ICP-MS).

This study mainly uses soil profile, correlation analysis, factor analysis and cluster analysis to study the material sources of soil heavy metals. Microsoft Excel 2016 and IBM Statistics SPSS18.0 software were applied for data processing and statistical analysis.

3. Source analysis of cadmium in soil

3.1. Source analysis of cadmium based on soil profile analysis

As shown in Fig. 1, the content of Cd was less affected by human activities in the depth range of 50 to 200cm, and the curve presents a downward smooth transition trend, indicating the small magnitude of change in Cd contents. However, in the depth range of 0 to 50cm, the surface soil was affected by alluvial deposition during flood period, and the Cd content showed a rapid increasing trend. Therefore, in the plain area along the Yangtze River, Cd content in the soil was stable to a certain extent under the influence of quaternary alluvial or diluvial deposits. While in the surface soil, Cd content was significantly increased under the influence of multiple factors such as soil secondary enrichment and anthropogenic factors. The results indicated that the accumulation of Cd to a certain extent in the surface soil was caused by the alluvial diluvium of the fourth system and human factors.

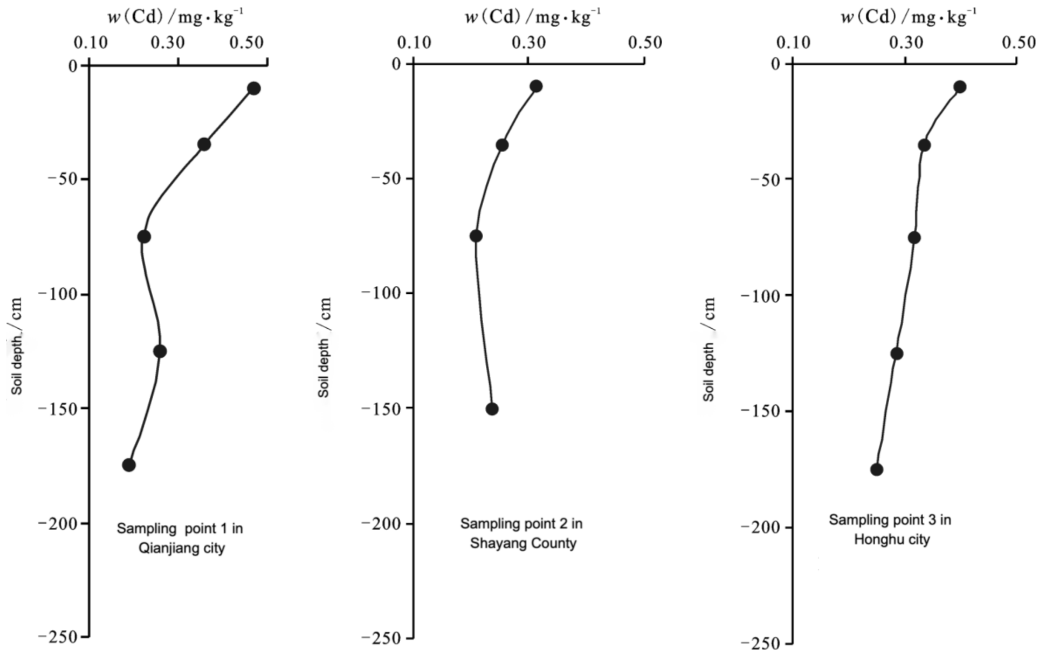

Figure 1. Variation of Cd content on vertical slope of typical soil

3.2. Source analysis of cadmium based on correlation analysis

The correlation analysis results of elements in the surface soil of the plain along the Yangtze River were shown in Table 1. The results showed that Cd had a good correlation with Cr, F, Mn, Mo, Ni, Se, Zn, TFe_2O_3, MgO and K_2O. The combination characteristics of Cd-Cr-Mo-Ni-Se were consistent with the typical element combination of the weathered parent material in the black clastic rock series in the alluvial zone, reflecting that it is the product of sedimentary differentiation of materials in the alluvial zone. The Cd-F-Zn-TFe_2O_3-MgO-K_2O assemblage reflected the special geochemical composition based on biological vegetation and microbial enzyme environment. According to the results of agricultural geological survey in Jianghan Basin, it showed a typical biological enrichment.

Table 1. Correlation coefficient between soil cadmium and other indexes

Index	Correlation	Index	Correlation	Index	Correlation	Index	Correlation	Index	Correlation
As	0.197	Cu	0.299	Mn	0.342	Pb	0.280	TFe_2O_3	0.341
B	-0.079	F	0.418	Mo	0.372	S	0.131	MgO	0.393
Cl	-0.018	Ge	0.176	N	0.295	Se	0.532	CaO	0.178
Co	0.264	Hg	0.061	Ni	0.464	Zn	0.578	Na_2O	-0.054
Cr	0.39	I	0.089	P	0.227	SiO_2	-0.403	K_2O	0.425

3.3. Source analysis of cadmium based on factor analysis

Through factor analysis of 8 heavy metals and Se in the surface soil of the plain along the Yangtze River, three principal components were extracted, which explained 72.88% of the total variance of the 9 indicators in general (shown in Table 2 and Table 3). Factor 1 mainly reflected the composition information of Ni, Cr, Cu, Se and Cd, the contribution rate was 34.5%, and the loads were 0.909, 0.867, 0.723, 0.554 and 0.484, respectively. The elements showed a strong positive correlation, indicating the similar sources. From the element composition characteristics, the surface soil composition belongs to the typical element combination of black rock series. This indicated that factor 1 was mainly affected by the parent material of the soil, and there is no pollution in the risk assessment of soil Cr element in this area, which further proved that Cr was mainly controlled by the parent material of the soil. Therefore, we inferred that factor 1 was a natural source, which is influenced by the parent material of the soil.

Factor 2 mainly reflected the composition information of Pb, Zn and Cd in soil with a contribution rate of 19.43%, and the loads were 0.900, 0.850 and 0.553, respectively. The elements showed a strong positive correlation, indicating that they had similar sources. Some studies have shown that Pb and Zn mainly come from the deposition of automobile exhaust, and Pb is the identification element of automobile exhaust [3]. Agricultural chemicals (herbicides, fungicides and insecticides, etc.) contain Cd elements, unreasonable application will lead to its enrichment in soil. The wastes produced by industrial production activities contain a large amount of Hg, Cd and Pb, and long-term input makes them accumulate in the soil, resulting in an increase in content [4]. Therefore, factor 2 was inferred to be anthropogenic sorces, mainly influenced by traffic, industrial and agricultural activities.

Table 2. The component and rotated component matrix of soil

Elements	Components			Rotated Components		
	1	2	3	1	2	3
As	0.534	0.749	-0.095	0.190	0.183	0.630
Cd	0.674	-0.140	0.258	0.764	0.086	0.034
Cr	0.811	-0.122	-0.334	0.826	0.073	0.053
Cu	0.637	-200	-0.286	0.476	0.695	1.020
Hg	0.191	0.897	-0.127	0.087	-0.229	7.070
Ni	0.852	-0.173	-0.316	0.803	0.383	0.820
Pb	0.457	0.134	0.774	-0.138	0.345	5.260
Se	0.658	-0.118	0.066	0.794	-0.014	0.087
Zn	0.423	0.607	-0.424	0.059	0.850	0.041

Table 3. Analysis of soil factor characteristic values

Factors	Initial eigenvalue			Extraction sum of squares and loaded			Rotated sum of squares loading		
	Total	Variance (%)	Accumulation (%)	Total	Variance (%)	Accumulation (%)	Total	Variance (%)	Accumulation (%)
1	3.295	36.606	36.606	3.295	36.606	36.606	2.834	31.493	31.493
2	1.262	14.018	50.625	1.262	14.018	50.625	1.569	17.437	48.930
3	1.052	11.690	62.315	1.052	11.690	62.315	1.205	13.385	62.315
4	0.935	10.391	72.706						
5	0.818	9.089	81.795						
6	0.550	6.113	87.908						
7	0.502	5.581	93.489						
8	0.390	4.331	97.820						
9	0.196	2.180	100.000						

3.4. Source analysis of cadmium based on cluster analysis

According to the results of cluster analysis of elements in the soil of the plain along the Yangtze River (Fig. 2), Ni, Cr and Zn were in the same population, which indicated significantly correlated, and may come from the parent material of the soil. Cu, Cd and Se were in the same population, especially Se and Cd were well correlated, indicating that they may have the same source and regionally correspond to the black rock series in western Hubei. Pb, As and Hg belonged to the same population, indicating the source of transportation and industrial production activities.

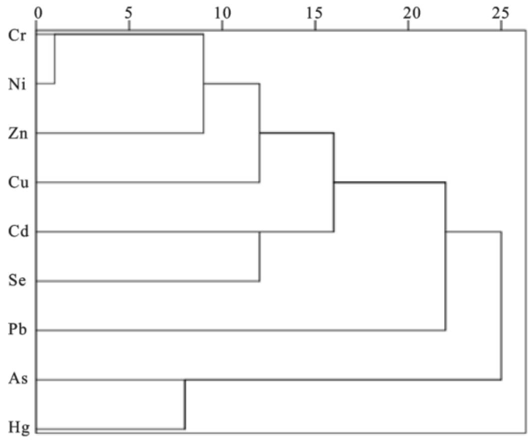

Figure 2. Clustering tree diagram of heavy metals in soil

4. Conclusion

Based on the analysis of heavy metal cadmium pollution in soil in Hubei Province, the source of cadmium in soil was revealed by soil profile analysis, correlation analysis, factor analysis and cluster analysis. It was found that the main element was mainly controlled by the parent material of black clastic rock series in alluvial zone and industrial and agricultural activities. The results of this study can provide scientific basis for soil heavy metal control and protection in Hubei Province.

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