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THE CORRESPONDING ANALYSIS OF HEAVY-METAL POLLUTION OF SOIL IN ZHUZHOU CITY

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ABSTRACT: The heavy-metal contents of various soil specimens in the urban district of Zhuzhou City are monitored and analyzed. On the basis of standardizing processing of monitoring data, the method of corresponding analysis is taken to divide the types of spatial geographic distribution of heavy-metal pollution of soil in the the area nearby industrial pollution source has high content and pollution index of Ca; most of soil is affected by many heavy-metals; paddy field is mainly polluted by Pb. It can provide scientific basis for the defensive ways of heavy-metal pollution of soil of farmland in urban district and for the reasonable utilization and a long-range plan of land.

KEY WORDS: heavy-metal pollution of soil, corresponding analysis, Zhuzhou City

I. INTRODUCTION

Zhuzhou City, which was called Jianning aciently and located in the east of Hunan Province, by the east of the middle Xiangjiang River, is a new industrial city in Hunan Province. The city attaches hills and rivers, and has many factories, such as smeltery, fertilizer factory, nitrogenous fertilizer factory, phosphate fertilizer factory, ore dressing factory, caustic soda factory, amounting to more than five hundred. Among them, some factories, such as smeltery, fertilizer factory, phosphate fertilizer factory and so on, discharge harmful gases containing sulphuric dioxide, chlorine, oxygen nitride, fluoride, etc. and poisonous waste water containing such heavy-metals as Hg, Cd, Pd, Zn, Cu; the amount of the pollutant is large, and the type of the pollutant is various. The pollution of soil is preliminarily caused by the gas pollutants which float into soil by the agency of gravity or the water pollutants which enter into soil with irrigation.

Soil is the pivot of substance and energy exchanging in natural environment system, and the exsisting status and the phsical, chemical, biological attributes of soil must change, when substance and energy are sent into soil system from its backgound environment. With the devolopment of towns, factories and enterprises, a large amount of pollutant enter into soil via atmosphere and irrigation in the process of production, which causes the damage of the balance of soil eco-system, the aggravation of soil formation and function, and the descending of the qaulity of soil environment. And the heavy-metal pollution is the main factor of destroying soil environment, more seriously, the heavy-metal in soil may accumulate in human and livestock's body through food chain and do harm to human being's health and demostic animal's devolopment directly. Thereby, it is meaningful on theory and practice to monitor, analyse, study the status and distribution regulation of heavy-metal pollution of soil.

II. THE METHOD OF STUDY

1. Investigation and Sampling

From April to May in 1992, we took an investigation on pollution source in Zhuzhou City's main factories such as smeltery, nitrogenous fertilizer factory, ore dressing factory, phosphate fertilizer factory, pesticide factory etc., to grasp their producing process and the status of discharging pollutants. We found that by investigation and the relevent statistic data of local environmental protection agency, the distribution could be divided into two types according to the pollution ways:

1) Irrigation pollution: Before the 1980s, the undisposed waste water of smeltery, fertilizer factory were used to irrigate, and the heavy-metals did harm to crops viatheir roots;

2) Gas-type pollution: It is the primary pollution method at present and poisonous gases and descending dust, floating dust do harm through crop leaves and root absorption. Hence, we arranged and collected specimens according to local climatic feature and pollution meteorological condition, and arranged 18 specimen points in sum with smeltery as a center. Area of each specimen point is 50 mm×50 mm, the depth of sampling is: layer A 0—5 cm, lay-

er B 5—10 cm, layer C 10—15 cm, layer D 15—20 cm. The situation of arranging specimen points and the distribution of pollution sources in the urban district is shown in Fig. 1. In respect of land use, specimen points 7—13 are paddy fields, the others are vegetable land.

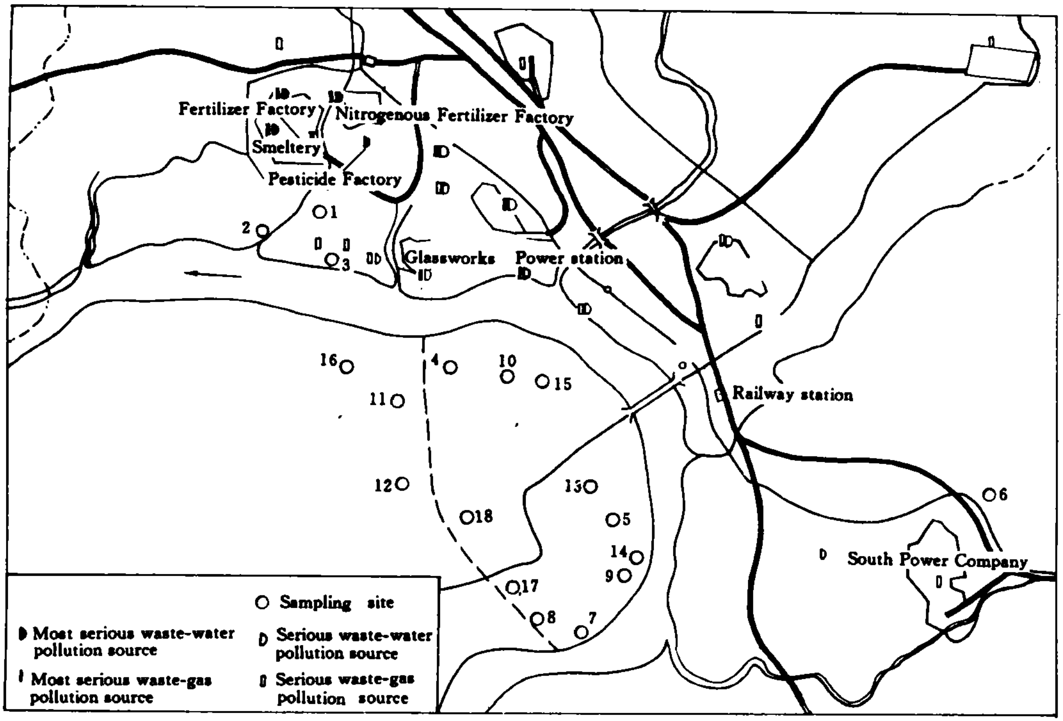

Fig. 1 Distribution of pollution sources and arrangment of specimen sites

2. The Indoor Analysis of Heavy-Metal Content in Soil

After being gathered, the soil specimens are air-dried, grund, sifted through nilon sifter, placed in a bottle, shaken thorougly, and finally made as specimen. The total contents of Cu, Pb, Zn,Cd in the soil can be digested in aquaperchloris acid, and the soluable can be extracted with 0. 1 M hydrochloric acid, filtered 24 hours later, and the ratio of soil and water is 1 to 5, then the contents can be determined by model 18080 atomic absorption photometer. After being digested with nitric acid—sulfuric acid, the content of Se in soil can be monitored with diethlene diaminodipheny potash acid silver, and the content of Hg in soil can be monitored with Jiangsu CG-IA cold atomic absorption apratus after being diested with nitric acid—sulfuric acid. After monitoring the content of each heavy-metal in each layer of each specimen point, the arithmetic mean of the four layers is taken as the content of heavy-metal of each specimen point.

3. Data Processing

According to the feature of ecological environment index system, the monitoring data of each pollution index are processed to increase analysis precision. The calculation formula of each pollution index of heavy-metal is:

$$P_i = \frac{C_i}{S_i}$$

where C_i is the monitoring consistency of heavy-metal in soil, and S_i is the assessment criteria of each heavy-metal.

As soil is an open system, the substance and energy exchanging with environment makes its components very complicated, and the unified environment assessment criteria of soil pollution have not existed abrood at home at present, so we took the value of pollution starting monitored by local environment monitoring agency as assessment criteria, the formula is:

$$S_i = \overline{X_i} + 2Q_i$$

where $\overline{X_i}$ is the average value of background of each heavy-metal, Q_i is the variance. The calculating soil environment qaulity criteria are shown in Table 1.

Table 1 Assessment criteria* (unit: mg/kg)

Item	Cu	Pb	Zn	Cd	As	Hg
Average background value	26.01	31.87	50.67	0.28	16.56	0.20
Pollution starting value	61.61	54.31	124.67	0.49	23.74	0.34

* Source: "The Report of Environment Qaulity Assessment in Zhuzhou City" by Zhuzhou Environment Monitoring Center Station and Zhuzhou Environment Research Agency, 1985.

The calculated values of each index are given in Table 2.

III. CORRESPONDING ANALYSIS

Corresponding analysis can integrate sample analysis (Q-type analysis) and variable analysis (R-type analysis), which are opposite in surface and relative in content. It synthesizes the merits of primary component analysis and factor analysis and decreases the quantities of calculation greatly, so that it's very useful in environment system analysis. In light of the shortcoming of factor analysis separating R-type analysis and Q-type analysis and omiting much useful information, the corresponding analysis integrate R-type analysis and Q-type analysis, reflecting variable and samples in the same coordinate axis(factor axis) in a figure simultaneously, so that it is convenient to explain and analyse the researching object, at the same time, corresponding analysis can obtain the output of Q-type analysis from the output of R-type analysis, conquering the difficulty of Q-type analysis which caused by large samples.

Table 2 Index of heavy-metal pollution of soil

Specimen point	Cu	Pb	Zn	Cd	As	Hg
1	1. 21	12. 35	5. 28	18. 76	2. 38	2. 79
2	1. 09	5. 99	2. 95	7. 78	2. 43	1. 15
3	0. 83	8. 45	3. 84	12. 78	2. 18	2. 21
4	0. 41	3. 37	1. 28	3. 82	1. 20	0. 91
5	0. 42	1. 01	0. 73	1. 06	0. 99	0. 79
6	0. 79	1. 13	1. 77	1. 08	1. 03	2. 21
7	0. 46	2. 28	1. 20	2. 55	0. 95	0. 41
8	0. 45	2. 14	1. 23	2. 31	0. 95	0. 59
9	0. 37	1. 15	0. 83	0. 51	0. 88	0. 49
10	0. 45	2. 09	1. 23	0. 51	1. 02	0. 56
11	0. 36	3. 33	1. 22	1. 53	1. 15	0. 76
12	0. 44	2. 76	1. 39	0. 78	1. 22	0. 56
13	0. 36	0. 98	0. 78	0. 94	0. 73	0. 56
14	0. 36	0. 79	0. 68	0. 49	1. 09	0. 54
15	0. 36	0. 55	0. 81	0. 94	1. 02	0. 39
16	0. 39	2. 74	1. 31	3. 57	1. 29	0. 63
17	0. 39	2. 04	1. 00	3. 02	0. 98	0. 54
18	0. 34	1. 02	0. 67	0. 63	0. 88	0. 56

Inputing the processed monitoring data to electronic computer, and calculating according to the process of corresponding analysis, we took the calculated contribution rate of more than 90% as criteria in analysis, and selected the former two factors as primary factors. The two primary factors represent 93. 38% information of total monitoring data, and the omited information only amounts to 8. 62%, the characteristic value of primary factors, capacity for load of R-type factors and Q-type factors are shown in Table 3, 4 and 5 seperately.

Table 3 Characteristic value and contribution rate of primary factors

	Characteristic value	Contribution rate	Accumulated contribution rate
F_1	0. 0831	0. 7849	0. 7849
F_2	0. 0136	0. 1288	0. 9138

* F_1: the first primary factor; F_2: the second primary factor

Table 4 Capacity for load of primary factors of R-type factors

	X_1(Cu)	X_2(Pb)	X_3(Zn)	X_4(Cd)	X_5(As)	X_6(Hg)
F_1	−0.1022	0.0195	−0.0791	0.1928	−0.1492	−0.0808
F_2	−0.0269	0.0927	−0.0088	−0.0523	−0.0125	−0.0367

Table 5 Capacity for load of primary factors of Q-type factors

	1	2	3	4	5	6
F_1	0.1366	0.0259	0.0935	0.0195	−0.0643	−0.1013
F_2	−0.0079	−0.0010	−0.0126	0.0218	−0.0287	−0.0466
	7	8	9	10	11	12
F_1	−0.0025	−0.0124	−0.0759	−0.0806	−0.0385	−0.0722
F_2	0.0058	0.0006	0.0041	0.0387	0.0569	0.0554
	13	14	15	16	17	18
F_1	−0.0586	−0.0902	−0.0653	0.0139	0.0156	−0.0695
F_2	−0.0126	−0.0180	−0.0371	−0.0019	−0.0132	−0.0067

According to the results in Table 4 and Table 5, we can draw the projection figure of each specimen point and each heavy-metal content in factor plane G_1-G_2, F_1-F_2, as being given in Fig. 2.

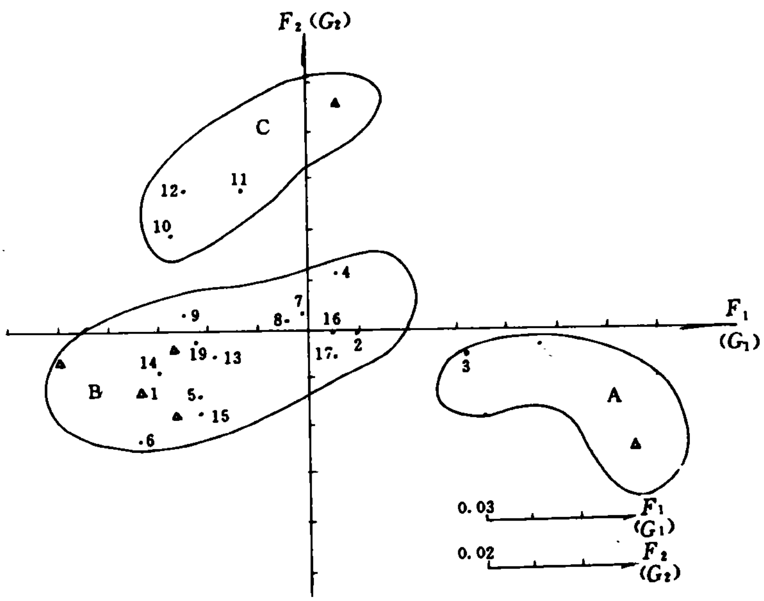

Fig. 2 A diagram for factors and their two capacities for load of primary facotrs

In Fig. 2, the variance contribution of the first factor axis (F_1) amounts to 78.44%, so, F_1 is the first primary factor axis in heavy-metal pollution factors in Zhuzhou City, being primary character of heavy-metal pollution in this district. We can see from Table 4 and Fig. 2 that the right of F_1 axis is Cd, the left is As, the variable which has the biggest capacity for load in F_1 is Cd (0.1928), being in the outmost right, the other characteristic coeffe cients , according to their capacity for load in F_1 successively are Zn ($-$0.0791), Hg($-$0.0808), Cu($-$0.1022), As($-$0.1429). The variance contribution of the second factor axis(F_2) only amount to 12.88%, and the variable which has the biggest rate of capacity for load is Pb(0.0927), the others have little rates in F_2, and are controlled by F_1 basically. F_1 and F_2 reflect the subsiding order of heavy-metal elements and their moving and transforming regulation under present meterological condition primarily.

For further analysis according to the natural polymerization tendency of variables and samples in Fig. 2 we divided all variables and samples into A, B, C zones. Then, we can explain them according to the meaning of variables contained in certain soil district. Zone A exists on the right of the first factor axis, showing the soil in zone A contains Cd particularly and obviously. The specimen points in this zone are all nearby industrial pollution source such as smeltery, fertilizer factor and steel factor, effected by waste water irrigation continously, and existing directly in the lee wind direction. The value of soil pH is acid particularyly and the solubility of Cd increases and can shift easily in soil. The landuse pattern is planting vegetable, because of using thioammonia and sulphate fertilizer, the accamulation of Cd become more easily, so the content and pollution index of Cd are higher than those of the specimen points. Zone B exists on the left and middle of the first factor axis, and includes major variables and samples in this district. Soil in this zone is effected by many heavy-metals: soil on the left of F_1 axis is effected by As, and the soil on the middle is effected by Pb, Zn, Hg. The landuse is complicated fairly: there is vegetable land, and paddy soil too. Specimen points 2, 4, 15, 16 exist nearby water, the others are far away from pollution source, thereby, the soil heavy-metal pollution in this zone has transitional character, the heavy-metal pollution factors are complicated. Zone C exists on the upper of the second factor axis, and is controlled by the second factor primarily. The landuse methods are all paddy fields, the exchanging of oxidation and reduction is freqent so the distance from the primary pollution source is moderate, being convenient for the accumulation of Pb, so its heavy-metal pollution is the pollution of Pb primarily.

IV. CONCLUSION

1) For different soil samples, because of the different distances from pollution sources, the different landuse methods and different chemical and physical properties of soil, the degree of heavy-metal pollution is different.

2) Different heavy-metal elements in different soil types and different landuse methods have different pollution character, so we point out that the control methods of heavy-metal pollution of different soil types are different.

3) Using corresponding analysis, integrating R-type and Q-type analsis, can reflect the status of soil heavy-metal pollution and its spatial distribution regrlation in Zhuzhou City.

4) The quantitative results of R-type and Q-type capacity for load of corresponding analysis can provide scientific basis for the reasonable devolopment of society, economy, and environment in Zhuzhou City, especially for the reasonable landuse, soil ecological environment planning.

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