Evaluation on Heavy Metal Pollution of Soil in Pollution-free Agricultural Product Bases in Guangxi

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Abstract Using data of 6 pollution-free agricultural product bases in Guangxi Zhuang Autonomous Region, this paper analyzed content of heavy metals, including arsenic (As), mercury (Hg), lead (Pb), cadmium (Cd), and chromium (Cr) in soil. After Pb, Cd, Cr, Hg and As content in soil is determined, it evaluated the pollution of soil using single factor pollution index method and Nemerow synthetic pollution index method in combination with evaluation standard of heavy metals in soil and grading standard for soil pollution. Analysis results indicate that As, Hg, Pb, Cd, Cr content is different in pollution-free agricultural product bases, but all conform to related standards and there is no standard exceeding problem. It is concluded that the quality of soil in pollution-free agricultural product bases is excellent, not polluted and completely meet requirements of evaluation standards, and suitable for developing pollution-free agricultural products.

Key words Pollution-free, Agricultural product bases, Soil, Heavy metals

1 Introduction

With rapid social and economic development, China's urbanization process is constantly accelerating and urbanization level is also rapidly improving. At the same time, however, it also brings serious environmental pollution and exerts serious influence on quality of agricultural ecological environment[1-5]. Environment quality is a fundamental factor influencing quality of agricultural products. Therefore, analyzing and evaluating heavy metal pollution of major agricultural products and production region environment (soil and water source), and determining the pollution level are of great significance to ensuring our health and providing scientific basis for further development of agricultural products and production of green agricultural products.

Harmlessness is the minimum requirement for safety of agricultural products. Pollution-free agricultural products are products with production region environment, production process, and target product quality conforming to national or industrial standard and production specifications for pollution-free agricultural products, and the quality passing the inspection of production region and market quality supervising authorities, and sold with identification of pollution-free agricultural products. With increasing concern for safety of agricultural products, it becomes particularly important to energetically develop production of pollution-free agricultural products, raise industrial level of agricultural products and improve quality of agricultural products[6-10].

Pollution and prevention of heavy metals in soil are always key and difficult issues in research of pollution ecology. On the basis of survey in 6 pollution-free agricultural product bases in Guangxi Zhuang Autonomous Region, we analyzed heavy metal pollution of soil, in the hope of providing theoretical and testing basis for understanding situation of ecological environment quality and carrying out environmental pollution control.

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2 Experiment and methods

2.1 Experimental methods

2.1.1 Analysis methods of heavy metals in soil. In this study, we mainly measured Pb, Cd, Cr, Hg, and As content in soil of production region of pollution-free agricultural products. Pb and Cd were analyzed with reference to *Soil Quality Determination of Lead, Cadmium - Graphite Furnace - Atomic Absorption Spectrophotometry* (GB/T17141 - 1997); *Cr was analyzed in compliance with Soil Quality Determination of Total Chromium - Flame Atomic Absorption Spectrophotometry* (GB/T17137 - 1997); As was analyzed in accordance with *Soil Quality Determination of Total Arsenic - Silver Diethyldithiocarbamate Spectrophotometry* (GB/T17134 - 1997); Hg was analyzed according to *Soil Quality Determination of Total Mercury - Cold Atomic Absorption Spectrophotometry* (GB/T17136 - 1997).

2.1.2 Evaluation methods for heavy metal pollution of soil. We adopted single factor pollution index method and Nemerow synthetic pollution index method to evaluate heavy metal pollution of soil. The current pollution situation is visually reflected through calculation[11-15].

The calculation formula of pollution index is as follows:

$$I_i = C_i / S_i$$

where I_i is the pollution idex of the i - th pollutant in the environment; C_i is the measured content of the i - th pollutant; S_i is the standard evaluation value of the i - th pollutant.

The calculation formula of Nemerow synthetic pollution index is as follows:

$$P_j[(P_{j\max}^2 + P_j[(P_{j\text{ave}}^2)/]^{1/2}$$

where $P_{j\max}$ is the maximum value of pollution index of all pollutants in the monitoring points and $P_{j\text{ ave}}$ is the average value of pollution index of all pollutants in the monitoring points.

Table 1 Grading of pollution index of heavy metals in soil or plant

Pollution index	Grade	Pollution grade	Pollution level
$I \leqslant 0.7$	1	Safe	Clean
$0.7 < I \leqslant 1$	2	Alarming line	Moderately clean
$1 < I \leqslant 2$	3	Mild pollution	Soil crops are polluted
$2 < I \leqslant 3$	4	Medium pollution	Soil crops are moderately polluted
$I > 3$	5	Serious pollution	Soil crops are seriously polluted

Table 2 Limit of content of elements in soil of pollution-free vegetable bases (mg/kg)

Standard	Pb	Cr	Cd	Hg	As
pH < 6.5	250	150	0.30	0.30	40
6.5 ≤ pH ≤ 7.5	300	200	0.30	0.50	30
pH > 7.5	350	250	0.60	1.0	25

2.2 Evaluation methods for heavy metal pollution of soil The evaluation of upper limit of harmful elements in soil was carried out in accordance with *Procedural Regulations regarding the Environment Quality Monitoring of Soil* (NY /T395 – 2000)[11] and *Pollution-free Food Environmental Requirements for Producing Areas of Vegetables* (NY 5294 – 2004).

3 Results and analyses

3.1 Analysis on content of heavy metals in soil of pollution-free agricultural product bases From Table 3, we can know that in all 6 pollution-free agricultural product bases, the Cr content in soil was 24.3 – 78.6 mg/kg; Pb content was 22.3 – 51.2 mg/kg; Cd content was 0.0022 – 0.28 mg/kg; Hg content was 0.061 – 0.269 mg/kg; As content was 5.7 – 30.2 mg/kg. All values are lower than standard value for pollution-free soil.

3.2 Evaluation of heavy metal pollution of soil From Table 4, it can be seen that taking limit of pollution-free soil quality, Hg, Pb and Cr are clean in all 6 pollution-free agricultural product bases, As and Cd reach the alarming level in some bases, but the soil is moderately clean. Therefore, the soil quality in those pollution-free agricultural product bases is suitable for producing pollution-free agricultural products.

Table 3 Heavy metal content of soil in different regions (mg/kg)

Sampling point	pH	Pb			Cr			Cd			Hg			As		
		Min.	Max.	Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.	Average
A	7.26	41.3	51.2	45.5	0.081	0.166	0.118	19.8	26.1	22.5	38.2	46.8	40.5	0.21	0.28	0.24
B	6.64	33.5	46.7	39.7	0.123	0.259	0.216	20.8	30.2	25.1	56.6	78.6	69.4	0.0059	0.011	0.0074
C	6.85	22.3	31.5	29.9	0.085	0.17	0.14	5.7	7.3	6.9	24.3	41.6	34.8	0.046	0.088	0.063
D	7.39	29.6	43.9	35.5	0.061	0.095	0.075	13.2	18.1	14.2	35.8	39.7	38.1	0.086	0.23	0.15
E	7.09	38.1	50.6	42.2	0.168	0.269	0.233	20.2	30.1	25.4	55.9	70.1	61.7	0.0022	0.0078	0.0048
F	7.38	41.5	46.5	42.3	0.111	0.137	0.123	8.15	17.4	13.5	41.6	44.7	42.4	0.077	0.09	0.09

Table 4 Evaluation of heavy metal pollution of soil in different regions

Sampling point	Type of heavy metal	Average pollution index ($P_{j\text{ ave}}$)	Max. pollution index ($P_{j\max}$)	Synthetic pollution index (P_j)	Evaluation result
A	Pb	0.15	0.17	0.16	Safe
	Cr	0.20	0.23	0.22	Safe
	Cd	0.80	0.93	0.87	Alarming line
	Hg	0.24	0.33	0.29	Safe
	As	0.75	0.87	0.81	Alarming line
B	Pb	0.13	0.16	0.14	Safe
	Cr	0.35	0.39	0.37	Safe
	Cd	0.02	0.04	0.03	Safe
	Hg	0.43	0.52	0.48	Safe
	As	0.84	1.01	0.93	Alarming line
C	Pb	0.10	0.11	0.10	Safe
	Cr	0.17	0.21	0.19	Safe
	Cd	0.21	0.29	0.26	Safe
	Hg	0.28	0.34	0.31	Safe
	As	0.23	0.24	0.24	Safe
D	Pb	0.12	0.15	0.13	Safe
	Cr	0.19	0.20	0.19	Safe
	Cd	0.50	0.77	0.65	Safe
	Hg	0.15	0.19	0.17	Safe
	As	0.47	0.60	0.54	Safe
E	Pb	0.14	0.17	0.16	Safe
	Cr	0.31	0.35	0.33	Safe

To be continued

Continued Table 4

Sampling point	Type of heavy metal	Average pollution index ($P_{j\,ave}$)	Max. pollution index ($P_{j\,max}$)	Synthetic pollution index (P_j)	Evaluation result
	Cd	0.02	0.03	0.02	Safe
	Hg	0.47	0.54	0.50	Safe
	As	0.85	1.00	0.93	Alarming line
F	Pb	0.14	0.16	0.15	Safe
	Cr	0.21	0.22	0.22	Safe
	Cd	0.30	0.30	0.30	Safe
	Hg	0.25	0.27	0.26	Safe
	As	0.45	0.58	0.52	Safe

4 Conclusions

Through determination of Pb, Cd, Cr, Hg and As content in soil of pollution-free agricultural product bases in Guangxi Zhuang Autonomous Region, it evaluated the pollution of soil using single factor pollution index method and Nemerow synthetic pollution index method in combination with evaluation standard of heavy metals in soil and grading standard for soil pollution. The results show that major pollution-free agricultural products bases in Guangxi Zhuang Autonomous Region have excellent soil quality which is suitable for producing pollution-free agricultural products.

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(From page 57)

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