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The Distribution of Cu Content of Soil in Different Land Use Types in the Suburbs of Changchun City

Wei SU*, **Dongmei LIANG**, **Minghui CHEN**, **Guisheng SHEN**

Jilin Academy of Environmental Sciences, Changchun 130012, China

Abstract In order to understand the heavy metal contamination of Cu in the farmland soil in the suburbs of Changchun City, and reveal the distribution of Cu content of soil in different farmland types, we use the methods field survey and laboratory analysis, to analyze the Cu content of soil in different farmland types in the suburbs of Changchun City. Using SPSS statistical analysis software and ORING mapping software, we process the data of Cu content in 60 sampling points and draw the normal distribution map, and then analyze the distribution of Cu content of soil in different land use types. The results show that the Cu content of the farmland soil in the suburbs of Changchun City is between 41.71 mg/kg and 116.77 mg/kg, with an average of 53.35 mg/kg, and the content in all sampling points is higher than the background value; in terms of the Cu content of soil, different land use types are sequenced in descending order (vegetable field > paddy > dry land).

Key words Farmland soil, Cu content, Distribution

1 Introduction

In recent years, with economic development, more and more people focus on improving the quality of life, and lay particular emphasis on the quality and safety of agricultural products. The pollution problems concerning the suburban farmland as the most direct and the most important source of fresh agricultural products for urban residents are attracting more and more attention. Many studies have shown that with the acceleration of urbanization, the readjustment of urban function areas and the long-term industrial and mining activities surrounding the suburban farmland have resulted in different degrees of heavy metal pollution to the soil of the suburban farmland. The heavy metal pollution to the farmland in the suburbs of some China's cities has become more serious[1]; some cities have made survey and study of soil pollution in the suburbs[2], and Chengdu City has also made detailed survey of the quality and characteristics of slopes[3-4], but there are few comparative studies on the soil heavy metal content in different land use types. This paper selects three land use types (dry land, paddy and vegetable field) for the comparative study of Cu content of soil, in order to identify the distribution of Cu in the soil in the suburbs of Changchun City.

2 Experimental methods

2.1 Sample collection

2.1.1 Selection of sampling points. According to the distribution of land use types, 60 sampling points are set when collecting the soil samples, including 31 sampling points of dry land, 9 sampling points of paddy, and 20 sampling points of vegetable field.

2.1.2 Collection and preparation of the sample. The sampling points basically cover the suburbs of Changchun City. In the study area, the farmland soil samples are collected in accordance with different land use types and global positioning system (GPS) is used for positioning. There is ring distribution along the suburbs and there is dense distribution to the leeward side of the city. 0 – 20 cm surface soil is collected, and the open land is chosen as the soil sampling land. To avoid interference from the surrounding environment, the plastic or wooden spatula is used to collect the surface soil. After removing the animal and plant remains and gravel in the samples and evenly mixing the samples, the quartering method is used to take 1 kg of soil samples. The collected soil samples are placed into the zip-lock plastic bag and then it is sealed. The labels record the sampling location, date, number and farmland types, and they are brought to the lab. During the sampling, the surrounding landscape and environmental conditions are described and recorded.

2.2 Sample processing and analysis

2.2.1 Sample pretreatment. The collected soil samples are aired in the cool, dry, ventilated and clean room. When the soil is half dried, the clods are crushed, and litters, roots animal residues and other debris are removed. After drying, the samples are ground through 100-mesh sieve, and they are sealed for testing.

2.2.2 Sample analysis. The inductively coupled plasma – mass spectrometry (ICP – MS) method is used for the determination.

3 Results

Using SPSS statistical analysis software and ORING mapping software, we process the Cu content data of 60 sampling points and draw the normal distribution figure. Then we analyze the Cu content distribution in the soil of different land use types, and compare the differences in the Cu content between different land use types, to reveal the features of Cu content distribution in the farmland of the suburbs of Changchun City.

3.1 Overall characteristics of Cu content of farmland soil

There are great changes in the Cu content of farmland soil in the suburbs of Changchun City, and the Cu content of soil is high. In all 60 samples, the minimum value of Cu content is 41.71 mg/kg,

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* Corresponding author. E-mail: suwei-cn@163.com

and the maximum value of Cu content is 116.77 mg/kg. The Cu content of soil in all sampling points is higher than the background value of soil in Jilin Province[5], and the average content is 53.35 mg/kg, 3.53 times of the background value, with a significant cumulative effect. The Cu content of 54.2% of sampling points is in 50.00 – 60.00 mg/kg (Fig. 1, removing an abnormal value).

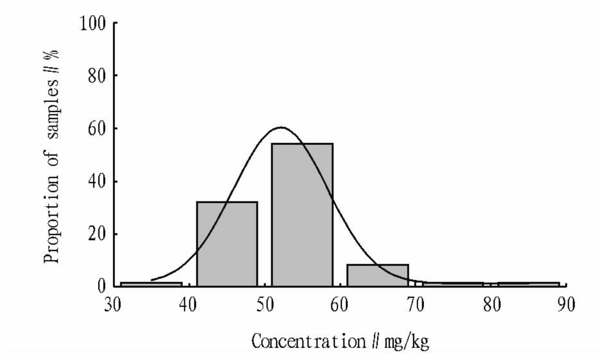

Fig. 1 The normal distribution characteristics of Cu content of the farmland soil in the suburbs of Changchun City

In the same land use type in the same area, the irrigation water quality differences will lead to Cu content differences. The Cu content of the farmland soil irrigated with water from Yitong River is much higher than the Cu content of the farmland soil irrigated with well water; the Cu content of the farmland soil in the sampling points down the prevailing wind is higher than the Cu content of the farmland soil in the sampling points up the prevailing wind; the Cu content of the farmland soil near the industrial zone is significantly higher than the Cu content of the farmland soil far away from the industrial zone; the Cu content of the farmland soil surrounded by livestock and poultry farm and solid waste dumps is also higher; the Cu content of the farmland soil with high application rates of manure and phosphate fertilizer is significantly higher than the Cu content of the farmland soil with high application rates of organic fertilizer.

3.2 The distribution of Cu content of the dry land soil The range of Cu content of dry land soil is 44.00 – 65.21 mg/kg, and the Cu content of soil in 77.4% of sampling points is within the range of 45.00 – 55.00 mg/kg (Fig. 2). The average Cu content is 3.32 times of the background value, with a significant cumulative effect.

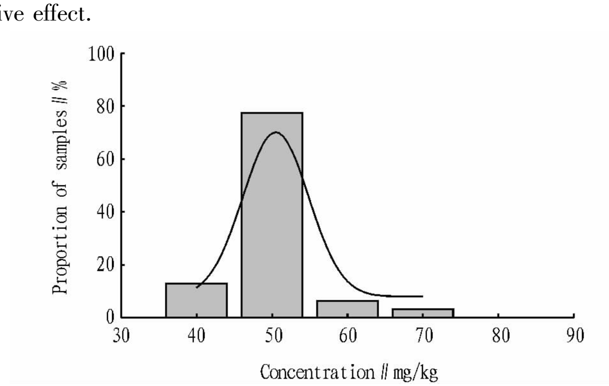

Fig. 2 The normal distribution characteristics of Cu content of the dry land soil in the suburbs of Changchun City

3.3 The distribution of Cu content of the paddy soil The Cu content of the paddy soil is within the range of 46.18 – 116.77 mg/kg, and the Cu content of soil in 50% of sampling points is within the range of 40.00 – 50.00 mg/kg (Fig. 3, removing the abnormal value). The average content is 3.37 times of the background value, with a significant cumulative effect.

The average Cu content of paddy soil is close to that of dry land soil, but there is abnormal Cu content of soil in this land type, and the maximum value reaches 116.77 mg/kg. There are great differences in the Cu content of paddy soil samples, indicating that Cu is accumulated more in individual paddy soils.

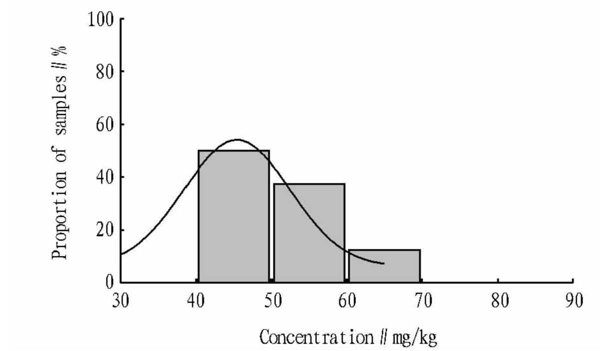

Fig. 3 The normal distribution characteristics of Cu content of the paddy soil in the suburbs of Changchun City

3.4 The distribution of Cu content of the vegetable field soil

The Cu content of the vegetable field soil is within the range of 41.71 – 70.46 mg/kg, and the content is higher than the background value. The Cu content of soil in 60% of sampling points is within the range of 50.00 – 60.00 mg/kg (Fig. 4), and the average content is 3.72 times of the background value, with a significant cumulative effect.

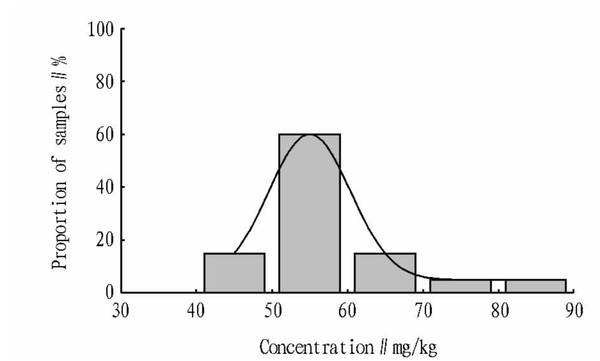

Fig. 4 The normal distribution characteristics of Cu content of the vegetable field soil in the suburbs of Changchun City

The average Cu content of the soil samples of vegetable field is the highest, indicating that the soil is significantly affected by the exogenous heavy metal contamination.

3.5 The differences in the Cu content of soil between different land use types Statistical analysis shows that there are significant differences between the Cu content of soil in dry land, paddy and vegetable field and the background value (Table 1), showing normal distribution (an unusually high value excluded from vegetable field and paddy, respectively). Cu is accumulated at different levels in the dry land, paddy and vegetable field.

In the three kinds of land use types, the average Cu content of dry land, paddy and vegetable field soils is higher than the background value. It is the highest in the vegetable field soil, reaching 54.61 mg/kg, followed by the paddy soil, and the Cu content of the dry land soil is the lowest, with an average of 50.09 mg/kg. The analysis of variance shows that the Cu content of vegetable field soil is significantly higher than the Cu content of dry land soil ($P<0.05$) and paddy soil ($P<0.05$) (Table 2).

Table 1 The characteristics of Cu content of the soil in different land use types

Land use types	Number of samples	Distribution type	Content//mg/kg		Exceeding the background value	
			Mean	Standard deviation	Number of samples	Percentage//%
Dry land	31	Normal distribution	50.09	5.16	31	100
Paddy	8	Normal distribution	50.96	4.90	8	100
Vegetable field	19	Normal distribution	54.61	6.78	19	100

Table 2 Variance analysis of differences in the Cu content of soil between different land use types

Significance test	Dry land	Paddy	Vegetable field
Dry land	–	–0.867	–4.519*
Paddy		–	–3.652*
Vegetable field			–

Note: *, $P<0.05$.

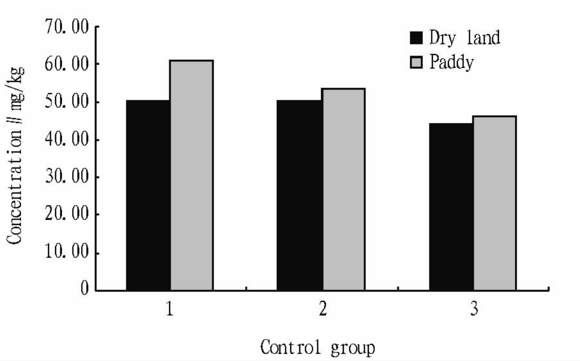

Fig. 5 The comparison of Cu content of soil between dry land and paddy

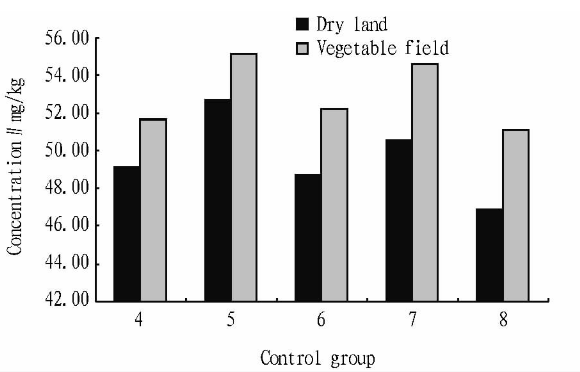

Fig. 6 The comparison of Cu content of soil between dry land and vegetable field

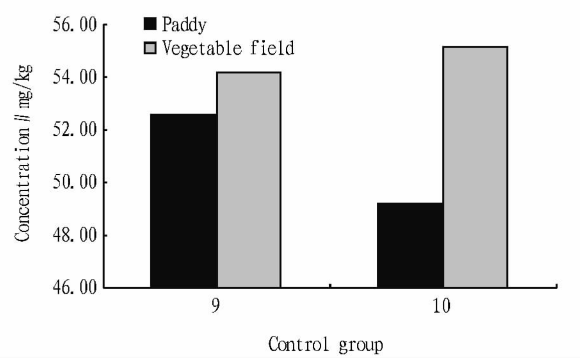

Fig. 7 The comparison of Cu content of soil between paddy and vegetable field

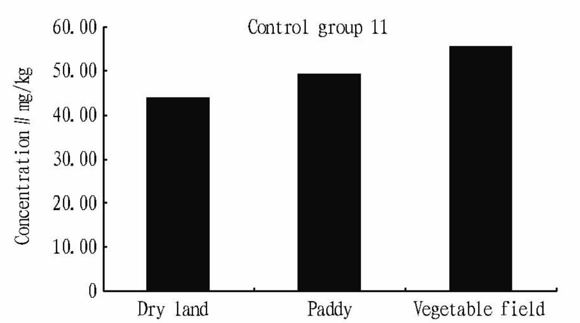

Fig. 8 The comparison of Cu content of soil between three land use types

We compare the Cu content of soil in different land types in close geographical proximity. A total of 11 control groups are selected for comparison. The dry land and paddy are compared in group 1 to 3; the dry land and vegetable field are compared in group 4 to 8; the paddy and vegetable field are compared in group 9 – 10; the Cu content of soil in three land use types is compared in group 11. The comparison results are shown in Fig. 5 – 8. In Fig. 5, the comparison of Cu content between the 3 control groups of dry land and paddy shows that the Cu content of paddy soil is higher than the Cu content of dry land soil, indicating that Cu is easier to accumulate in the paddy soil, and the exogenous impact on paddy is greater than the exogenous impact on dry land. In Fig. 6, the comparison of Cu content between the 5 control groups of dry land and vegetable field shows that the Cu content of dry land soil is lower than the Cu content of vegetable field soil, indicating that Cu is easier to accumulate in the vegetable field soil, and the exogenous impact on vegetable field is greater than the exogenous impact on dry land.

In Fig. 7, the comparison of Cu content between the 2 control groups of paddy and vegetable field shows that the Cu content of paddy soil is lower than the Cu content of vegetable field soil, indicating that the exogenous impact on vegetable field is greater than the exogenous impact on paddy. In Fig. 8, the comparison of Cu content between the three land use types shows that the Cu content of vegetable field soil is the highest, followed by the Cu

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content of paddy soil, and the Cu content of dry land soil is the lowest, indicating that in the three land use types, Cu is easier to accumulate in the vegetable field soil, and the exogenous impact on the vegetable field is the greatest.

Studies have shown that the comparison results of 11 control groups are the same as the comparison results of the average Cu content of soil between three land use types.

4 Conclusions

There are great changes in the Cu content of farmland soil in the suburbs of Changchun City, and the Cu content of soil is high. In all 60 samples, the minimum value of Cu content is 41.71 mg/kg, the maximum value of Cu content is 116.77 mg/kg, and the average content is 53.35 mg/kg. The Cu content of soil in all sampling points is higher than the background value of soil in Jilin Province. There are significant differences between the Cu content of soil in dry land, paddy and vegetable field and the background value (Table 1), showing normal distribution (an unusually high value excluded from vegetable field and paddy, respectively). Cu is accumulated at different levels in the dry land, paddy and vegetable field. In Fig. 5, the comparison of Cu content between the 3 control groups of dry land and paddy shows that the Cu content of paddy soil is higher than the Cu content of dry land soil, indicating that Cu is easier to accumulate in the paddy soil, and the exogenous impact on paddy is greater than the exogenous impact on dry land. In terms of the Cu content of soil, different land use types are sequenced in descending order (vegetable field > paddy > dry land). The average Cu content of vegetable field soil is the highest, reaching 54.61 mg/kg, followed by the paddy soil, and the Cu content of the dry land soil is the lowest, with an average of 50.09 mg/kg. The vegetable field is significantly affected by the exogenous heavy metal pollution. There are great differences in the Cu content of paddy soils, and Cu is accumulated more in individual paddy soils. The average Cu content of the dry land soil is the lowest, and its standard deviation is also the lowest, but the content differences are not significant. There are significant differences in the Cu content of soil in different land use types in different regions.

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