The Soil Heavy Metals Content and Distribution of Jiujiang City

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Abstract. Soil pollution is serious now worldwide especially in China, with the continuous expansion of industrialization, the problem of soil heavy metal pollution is becoming more and more serious which is toxic to human beings. We studied the content and distribution of Cu, Zn, Pb, Cr, and Cd in soil of Jiujiang city. The results showed that the content of Cr and Zn were higher than others and the content of Cd was the lowest. Meanwhile, the content of the same heavy metal element has no significant difference between samples in different depth of the sampling point as our studied.

Keywords: Soil pollution, Heavy metal, Content, Distribution.

1. Introduction  
Soil is an important natural resource, which is not only closely related to the development of human beings, but also to the environmental factors that related to human life. Soil plays a very important role in human existence, development and agricultural production which support human beings’ lives.  

However, with the continuous progress of industrialization, soil pollution is becoming more and more serious in recent decades. The soils lie at the junction of the atmosphere, the lithosphere and the hydrosphere so they can further affect the fresh water, ground water, biology, ecology and other environmental matrix when soils are polluted. With the emergence of many soil heavy metal environmental problems, the prevention and evaluation of soil heavy metal pollution has become a hot spot. It is urgent to prevent and control heavy metal pollution in soils.  

Heavy metals are toxic, which has an important impact on plants and animals closely related to soil, as well as all aspects of the entire biosphere. Soil heavy metal pollution has the characteristics of high toxicity, long-term, concealing and irreversibility. As the heavy metals in soil exist in soil for a long time, they do not tend to have the characteristics of biodegradation. In order to control the heavy metal pollution, it is necessary to invest more manpower and material resources and financial resources, and it is very difficult to restore the soil clean state. Therefore, it is necessary and profound to evaluate the soil heavy metal pollution situation.

Many investigations and studies have found that the sources of heavy metals entering the natural cycle can be divided into two categories: natural activities and human activities. Natural processes include geological tectonic movement, rock weathering and erosion, biological decay, volcanic eruption, and water-rock interaction, etc., resulting in different abundance and distribution characteristics of heavy metals in soil [1, 2]. Compared with human activities, heavy metals produced...
by natural processes have less impact on natural ecology. Sources of heavy metals related to human activities include agricultural, industrial and mining, domestic and transport pollution sources [3]. The unreasonable application of a large amount of sewage and chemical fertilizer has caused great pollution and potential heavy metal pollution to soil. For example, superphosphate, phosphate, calcium magnesium phosphate fertilizer and other fertilizers contain cadmium, lead, chromium and so on. Common preparations such as Heineken, Inagaoacin and Sarisan are rich in mercury and arsenic [4, 5]. Industrial waste residue, waste water, waste gas, mining and smelting processes are not perfect [6] and improper construction processes [7, 8], resulting in a large number of heavy metal raw materials are not effectively utilized and recycled, and enter the natural environment under long-term exposure and contact, resulting in heavy metal pollution. Domestic pollution sources include: stacking of household garbage and sewage discharge [9]. After long-term accumulation and disposal of household garbage, heavy metal diffusion and migration will occur, which is not easy to find, but many of them don't make sense. As a consequence, these heavy metals in the soil can also be absorbed by crops, ultimately posing a major threat to human health through the food chain. Once it appears in human daily life and production activities, probability begins to accumulate in the organism. When it reaches a certain concentration range, it will exceed the limit of human bearing capacity and cause irreparable damage to human health. Most of the heavy metals can cause serious human disease and bad long-term influence. Currently, data from the International Agency for Research on Cancer show that lead and lead compounds may be carcinogens in humans, but the evidence for human carcinogenesis is not strong enough. However, lead has a great impact on human health, especially on children's health, such as lead poisoning in children caused by non-standard operation of lead smelting enterprises. Zinc, like copper, is one of the essential trace elements in the human body. Excessive zinc inhibits enzyme activity and causes digestive tract symptoms such as headache, dizziness, nausea and vomiting, abdominal pain and diarrhea [10].

Recently, the research methods of soil heavy metals are gradually mature, and the experimental analysis and testing methods are more sophisticated. ICP-MS, ICP-OES, X-ray fluorescence spectrometer and other instruments are widely used in the analysis of heavy metal elements in soil [11]. There have been many reports of heavy metal pollution in soil combined with heavy metals in air and water. It also seeks to be more accurate in source analysis, such as Imperato et al studied the spatial distribution of heavy metals in the soil of Naples, Italy [12]. Based on the analysis of the lead content of the main automobile exhaust emission source in Naples, it is suggested that the main pollution source may be lead. Wear and tear on railway, tram tires and lines may be responsible for soil copper pollution. The relationship between soil particle size, magnetic properties and heavy metal content has attracted much attention. A large number of studies have shown that fine-grained soil can absorb more heavy metals due to its large specific surface area [12, 14]. Many studies have shown that the mass fraction of heavy metals (Cr, Cu, Pb, Zn) has a strong positive correlation with the magnetic parameters in soil, road dust or sediment. There are more and more reports on soil elements research based on remote sensing and electron microscopy. Remote sensing technology can not only detect the content of heavy metals in soil in a large area, but also has the advantages of low cost, fast speed and environmental protection [15]. Another notable feature of this period is that, with the increasingly close connection of the world, the rise of industry in some developing countries and the increasingly prominent problem of soil pollution in developing countries have attracted the full attention of all countries. Therefore, there are a large number of international reports and research results on soil heavy metal pollution in developing countries. For example, farmland near a landfill in Kolkata, India, has long suffered from heavy metal pollution caused by various types of waste [16]. Cu, As, Cd, Sb and Pb were significantly high in soil samples from an e-waste open air incinerator in Ghana [17]. The soil in most of the sampling sites in the Turkish river basin has been moderately polluted [18].

Based on the background stated above, we studied the heavy metals content in Jiujiang city. And tested different depth of the soil samples to get the pollution condition to evaluate the soil environmental condition.
2. Materials and methods

A. Study sites

Samples that were analyzed in this study were collected in Jiujiang city in different sites and different depth of the sampling sites.

B. Data and data sources

The data used in this study are provided by Zhongjiu Environmental Technology Co., Ltd. The data includes soil moisture content and heavy metal content of Jiujiang city.

C. Soil moisture content

Water content formula:

\[ \omega = \frac{m_2 - m_1}{m_0 - m_1} \times 100\% \]  

(1)

Where \( \omega \) is the water content, \( m_0 \) (g) is the mass of petri dish, \( m_1 \) (g) is the initial weight of petri dish and sample, \( m_2 \) (g) is the final weight of petri dish and dried sample.

The results of moisture content are shown in Table 1.

| Serial number | Moisture content /% |
|---------------|---------------------|
| 1-1           | 3.29%               |
| 1-2           | 3.05%               |
| 1-3           | 2.82%               |
| 2-1           | 2.60%               |
| 2-2           | 4.40%               |
| 2-3           | 3.44%               |
| 3-1           | 3.14%               |
| 3-2           | 3.48%               |
| 3-3           | 3.31%               |
| 4-1           | 4.02%               |
| 4-2           | 3.63%               |
| 4-3           | 4.21%               |
| 5-1           | 2.70%               |
| 5-2           | 1.68%               |
| 5-3           | 2.74%               |
| 6-1           | 3.35%               |
| 6-2           | 4.56%               |
| 6-3           | 2.96%               |
| 7-1           | 2.63%               |
| 7-2           | 2.25%               |
| 7-3           | 3.12%               |
| 8-1           | 6.57%               |
| 8-2           | 2.10%               |
| 8-3           | 2.75%               |
| 9-1           | 2.21%               |
| 9-2           | 1.81%               |
| 9-3           | 19.38%              |
| 10-1          | 3.79%               |
|   |    |
|---|---|
| 10-2 | 9.57% |
| 10-3 | 3.25% |
| 11-1 | 5.81% |
| 11-2 | 1.45% |
| 11-3 | 2.47% |
| 12-1 | 5.37% |
| 12-2 | 1.40% |
| 12-3 | 1.47% |
| 13-1 | 2.65% |
| 13-2 | 1.75% |
| 13-3 | 4.42% |
| 14-1 | 3.62% |
| 14-2 | 3.38% |
| 14-3 | 3.43% |
| 15-1 | 1.96% |
| 15-2 | 1.59% |
| 15-3 | 2.51% |
| 16-1 | 1.36% |
| 16-2 | 2.28% |
| 16-3 | 1.95% |
| 17-1 | 3.74% |
| 17-2 | 3.22% |
| 17-3 | 2.87% |
| 18-1 | 12.06% |
| 18-2 | 4.39% |
| 18-3 | 2.51% |
| 19-1 | 2.27% |
| 19-2 | 1.74% |
| 19-3 | 1.57% |
| 20-1 | 3.02% |
| 20-2 | 3.63% |
| 20-3 | 1.92% |
| 21-1 | 3.35% |
| 21-2 | 3.33% |
| 21-3 | 22.11% |
| 22-1 | 2.82% |
| 22-2 | 1.21% |
| 22-3 | 3.55% |
| 23-1 | 5.59% |
| 23-2 | 2.33% |
| 23-3 | 3.05% |
| 24-1 | 0.91% |
| 24-2 | 10.39% |
| 24-3 | 2.46% |
| 25-1 | 2.88% |
| 25-2 | 2.19% |
Note: X-1, X-2, and X-3 represent the first layer sample, second layer sample and third layer sample of sampling point X

D. Accuracy and precision

GBW07409 reference material for soil composition analysis.

The standard value and standard deviation of GBW07409 are shown in Table 4, and the maximum and minimum values can be calculated according to the standard value and standard deviation. The results are reflected in Table 2.

### Table 2 Standard values and standard deviations of standard soil samples

| Element | Standard value | Standard deviation | Lowest value | Maximum value |
|---------|----------------|--------------------|--------------|---------------|
| Cr      | 28.22          | 5.62               | 21.50        | 33.88         |
| Cu      | 25.45          | 4.63               | 21.90        | 31.55         |
| Zn      | 4.93           | 1.30               | 3.61         | 6.20          |
| Pb      | 16.3           | 2.40               | 13.90        | 18.70         |
| Cd      | 0.068          | 0.023              | 0.045        | 0.091         |
| Cr      | 26.4           | 2.10               | 24.30        | 28.50         |

The precision and accuracy of this experiment is by adding about 0.2000 g GBW07409 standard soil analytical material to the blank sample. The results are shown in Table 3.

### Table 3 results of blank sample labeling

| Sample | Cr (mg/kg) | Cu (mg/kg) | Zn (mg/kg) | Cd (mg/kg) | Pb (mg/kg) |
|--------|------------|------------|------------|------------|------------|
| 1      | 28.22      | 5.62       | 32.33      | 0.08       | 14.99      |
| 2      | 25.45      | 4.63       | 32.78      | 0.09       | 16.22      |
| 3      | 24.73      | 4.55       | 34.64      | 0.09       | 16.73      |
| 4      | 25.51      | 4.44       | 34.62      | 0.07       | 14.42      |
| 5      | 27.80      | 5.10       | 34.30      | 0.08       | 17.12      |

The relative standard deviation of heavy metal element Cr is 5.92%. The relative standard deviation of Cu is 10.07%, the relative standard deviation of Zn is 3.25%, the relative standard deviation of Cd
is 10.21%, and the relative standard deviation of Pb is 7.31%. The determination results of the five groups of data are all between the lowest value and the highest value of Table 4, and the accuracy also meets the requirements.

3. Results and discussions

A. heavy metal distribution in soils of Jiujiang city

As shown in Fig.1, the five different heavy metals distributed in soils of Jiujiang city differently.

**Fig. 1** Heavy metal distribution in soils of Jiujiang city.

The abscissa represents sampling sites and the ordinate represents the concentration of heavy metals. Different colors represent the corresponding depth as a line chart, in which black, red, and blue represent the surface layer, the middle layer, and the deepest layer. The figure 1a, 1b, 1c, 1d, 1e represent Cr, Cu, Zn, Cd and Pb respectively.
Through the above figure, it can be found that the contents of heavy metals in soils with different numbers fluctuate. The soil sample No. 20 had the highest Pb content and the soil sample No. 27 had the lowest Pb content. Except that the content of Pb in the deep soil of No. 25 decreased greatly. In each number, the depth of soil layer is not closely related to the content of Pb. The contents of Pb in shallow, middle and deep layers were basically the same. The Cd content of No.3 soil sample was the highest, and that of No.27 soil sample was the lowest. The content of Cd in the middle layer of No. 9 soil increased suddenly, and it was basically the same in the shallow layer and the deep layer. No. 17, the content of Cd in shallow soil was the highest, while that in middle and deep soil decreased greatly. In other numbers, the depth of soil layer is not closely related to the content of Cd. The contents of Cd in shallow, middle and deep layers were basically the same. The soil sample No. 10 had the highest Zn content and the soil sample No. 27 had the lowest Zn content. The fluctuation of Zn in different soil depths is obvious, and the sub-table is shown in No. 1, 2, 4, 17, and 18. The Zn content of No. 1 soil sample was the lowest in the surface layer, the highest in the middle layer and the lowest in the deep layer. The content changes obviously in these three layers. The content of Zn in the surface layer of No. 2 and No. 17 soil samples was the highest and the content of Zn in the middle layer was the lowest. The Zn content in the deep layer of the No. 4 soil sample decreased suddenly, and in the No. 18 soil sample, the Zn content in the middle layer was the same as that in the deep layer, and the Zn content in the shallow layer was the highest. In other numbers, the soil depth is not closely related to the Zn content, but the Zn content in the shallow, middle and deep layers is basically the same. The soil sample No. 21 had the highest Cu content, while the soil sample No. 27 had the lowest Cu content. Except for the great decrease of Cu content in the middle soil of No. 14. In each number, there was no significant correlation between soil depth and Cu content, but the Cu content in shallow layer, middle layer and deep layer was basically the same. The soil sample No. 9 had the highest Cr content while that in soil sample No. 27 was the lowest. Except for the great increase of Cr content in the deep soil of No. 26. In each number, there was no significant correlation between soil depth and Cr content, but the Cr content in shallow layer, middle layer and deep layer was basically the same.

In the distribution of five heavy metals, it can be seen that the content of heavy metals in No. 27 is the lowest in all numbers. This may be due to the fact that there is no industrial source pollution around the site of the sample collected on the 27th. Secondly, in the distribution of heavy metals in different depths, it can be seen that a small number of numbered heavy metals have undergone intense vertical migration, and most of them have not migrated. There are many factors that lead to this kind of migration. In previous studies, it can be found that: Heavy metals in soil can be transported by physical, chemical and biological media [19, 20]. In the actual process, heavy metals can be used alone. Depending on one kind of media to migrate, it can also be shown as a combination of multiple media, so its migration process is often extremely complex and difficult to predict [21-24]. The retention capacity and migration of heavy metals in soil are mainly controlled by the adsorption characteristics of heavy metals, and the factors affecting the adsorption characteristics include physical and chemical properties such as pH, soil particle size, organic matter, bulk density, redox potential and parent material layer. In addition to the influence of soil physical and chemical properties on the chemical adsorption of heavy metals in soil, various physical factors such as hydrodynamic dispersion, mixing and deposition also play a key role [25, 26]. Thus, it can be seen that there are many factors affecting the migration of heavy metals in soil, and the law of migration is not simple. The vertical migration of heavy metals studied in this paper may also be related to the physical and chemical properties of soil, such as pH, soil particle size, organic matter, bulk density, redox potential and parent material layer [27].

4. Conclusions

This paper studied the soil heavy metals concentration and content of Jiujiang city. The content of the same heavy metal element has no obvious relationship with the depth of the sampling point under the condition of ensuring the same sampling point but has a great relationship with the distribution of
different sampling point. The reason for this may be that heavy metals are less likely to migrate in the soil than in media such as air and water since the soil is a heterogeneous matrix [28]. The content of heavy metals in soil showed us the contents of Cr element and Zn element are higher, the average content of Cr element is 360 mg kg\(^{-1}\), and that of Zn element is 420 mg kg\(^{-1}\). The content of Cd is the lowest, with an average concentration of 1.35 mg kg\(^{-1}\). In the tested samples, the highest content of Cr, Zn, Cu, Pb and Cd was 911, 723, 132.49, 79.65 and 2.37 mg kg\(^{-1}\) respectively. However, for the comprehensive soil quality of Jiujiang City, the research is a complex and comprehensive process. In this paper, only five major heavy metal elements were selected as the main object of study, which is not comprehensive enough. The existing forms of soil total metal elements, soil nutrient elements, soil physical and chemical indexes, vertical samples, water samples, atmospheric dry and wet deposition samples, crop samples, organic samples and other existing forms should be added.

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