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Spatial Distribution Characteristics of Heavy Metals and Pollution Analysis Methods

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Abstract

With the rapid development of urban economy and the continuous increase of urban population, the discharge and improper disposal of a large number of industrial wastes, urban domestic garbage, sludge and other pollutants have led to the continuous accumulation of heavy metals in the soil, which has increased the pollution load of heavy metals in the soil, leading to the increasingly serious heavy metal pollution of urban topsoil in China. Heavy metal pollution of urban soil is one of the important indicators that can effectively reflect the status of urban environmental pollution. Therefore, the verification of urban soil environment anomalies and the application of verification data to urban environmental quality assessment, as well as the study of the evolution model of human activities affecting urban soil environment, have increasingly become the focus of attention. Based on the analysis of a large number of relevant documents and previous work, the sources, hazards and pollution status of soil heavy metal pollution in some regions of China are briefly summarized, and the characteristics of five commonly used assessment methods of soil heavy metal pollution (single pollution index method, comprehensive pollution index method, geo accumulation index method, potential ecological risk index method, principal component analysis method) are briefly analyzed and summarized, It is expected to provide some reference for the investigation and treatment of soil pollution.

Keywords

Heavy Metals; Spatial Distribution Characteristics; Evaluation Method.

1. Overview of Heavy Metal Pollution in Soil

Soil heavy metal pollution refers to the phenomenon that human activities introduce heavy metals into the soil, so that the content of heavy metals in the soil is significantly higher than the background value and exceeds a certain load capacity, causing existing or potential soil quality degradation, ecological and environmental degradation [11]. In the study of environmental pollution, according to the chemical properties and toxic characteristics of elements, the soil heavy metal pollution is generally dominated by Cd, As, Pb, Cr, Ni, Hg, Cu, Zn

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and other heavy metals with significant biological toxicity. The sources of heavy metals in soil are wide, which can be divided into natural sources and anthropogenic sources. The natural source is mainly affected by the parent material and the process of soil formation. Man made sources are the main causes of heavy metal pollution in soil, mainly including sewage irrigation, heavy use of pesticides and fertilizers, atmospheric sedimentation, transportation, and waste accumulation.

2. Hazards of Heavy Metal Pollution in Soil

Soil heavy metal pollution is characterized by concealment, hysteresis, long-term, irreversibility, and complexity. Its harm mainly causes crop yield reduction and quality decline. Soil heavy metal pollution will directly or indirectly harm the growth of crops, and finally lead to crop yield reduction, quality decline, or even death. In addition, heavy metals in the soil, especially in the topsoil, are very easy to enter the human body and directly endanger human health. Studies have shown that cadmium accumulates in the human body for a long time, and when it reaches a certain degree, it will damage renal tubules, cause calcium and phosphorus metabolism disorders, thus leading to bone decalcification, and may also cause cancer, teratogenesis, and mutation. When arsenic is accumulated in the human body to a certain extent, it will dissolve the red blood cells in the human body, thus damaging the normal physiological functions of the human body. At the same time, it is also hereditary, carcinogenic and teratogenic. Lead will lead to the decline of human immunity and reproductive function. When the blood lead content reaches 600~800 μg/g, the human body will have a series of symptoms such as headache, dizziness, abdominal pain, etc., which have a significant impact on children's physical health and intellectual development. After mercury enters the human body, it will be absorbed by the blood and rapidly diffused to the liver, lung, kidney and other organs, affecting the generation of energy, the synthesis of protein and nucleic acid, the normal growth and function of cells, and in serious cases, it will cause damage to the nervous system and kidney, causing death. Nickel has obvious developmental toxicity and reproductive toxicity to human body, which will cause adverse effects on fetal development and also affect human hematopoietic function. Chromium is an essential trace element for human body and plays an extremely important role in sugar metabolism and lipid metabolism. Chromium is mainly a chronic hazard to the human body. After long-term consumption of chromium containing food, skin and respiratory system will show varying degrees of pathological changes, accompanied by a series of symptoms such as ulcers and inflammation. Copper is also an essential trace element for the human body, but excessive copper can cause cirrhosis, vomiting, diarrhea, sensory disorders and other symptoms. Zinc is also an essential trace element for the human body. Research shows that excessive zinc will cause gastrointestinal discomfort, nausea, abdominal pain and a series of adverse reactions.

3. Assessment Method of Heavy Metal Pollution in Soil

The soil environmental quality standard is the basis for carrying out soil environmental assessment, and the comparison of the soil quality standard or the calculation of the assessment index is the most basic method for the assessment of soil heavy metal pollution. Since 1993, the International Organization for Standardization has successively issued some soil quality standards, and the United States and Japan have also formulated many soil environmental quality standards; In 1995, China issued the Soil Environmental Quality Standard GB 15618-1995, which defined the soil environmental quality standards for 8 metal elements, including arsenic, cadmium, mercury, lead, chromium, copper, zinc and nickel. On this basis, since the 21st century, China has successively issued such industrial standards as HJ/T 166-2004 Technical Code for Soil Environmental Monitoring, GB 15618-2018 Standard for Soil

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Environmental Quality and Risk Management and Control of Agricultural Land and Soil Pollution, and has made detailed provisions on soil environmental quality assessment. However, it is difficult to use a unified standard to evaluate the soil due to many external interference factors. Therefore, on the basis of national standards, the use of regional environmental soil background value and soil reference point content as soil environmental quality standards has also been widely applied.

At present, the common methods for risk assessment of soil heavy metal pollution mainly include single pollution index method, comprehensive pollution index method, geo cumulative index method, potential ecological risk index method, principal component analysis method, etc.

3.1. Single Pollution Index Method

The single pollution index method is based on the soil environmental quality standard to evaluate the pollution degree of a certain pollutant in the soil. It is the most basic and widely used evaluation method. The main pollutants and their harmfulness can be determined through single pollution index evaluation.

The single pollution index method first calculates the ratio of the content of heavy metals in the soil to the evaluation standard value to obtain the single index Pi. According to Pi size, soil pollution can be divided into 5 levels.

3.2. Comprehensive Pollution Index Method

The objective of single pollution index method is clear and easy to calculate, but it can only evaluate the single element of soil heavy metals, and cannot reflect the comprehensive situation of soil pollution. Therefore, a variety of comprehensive pollution index methods have been developed on the basis of single factor evaluation, and Nemerow index method is one of them. Since the Nemerow index method not only considers the maximum value of pollutants, but also considers the average value of pollutants, it can more objectively evaluate the pollution status of soil heavy metals, and is one of the comprehensive evaluation methods widely used at home and abroad.

3.3. Geo Cumulative Index Method

In 1969, German scientist Muller first proposed the geo accumulation index method, which is widely used to study the pollution degree of a certain heavy metal in sediment or soil. The geo cumulative index method reflects the natural distribution characteristics of heavy metal elements to a certain extent, and can evaluate the impact of human activities on heavy metal pollution.

3.4. Potential Ecological Risk Index Method

The potential ecological risk index method is a method proposed by Swedish Geochemist Hakanson to evaluate the potential risk degree of heavy metals in sediments, which can comprehensively reflect the pollution of heavy metals on soil, and has been widely used in the assessment of potential ecological risk of heavy metals in soil.

3.5. Principal Component Analysis

Principal component analysis refers to finding out the characteristic quantities of its variance and covariance matrix in a group of variables. Through the statistical analysis method of transforming multiple variables into a few comprehensive variables, the new variables contain the information of the original variables and are not related to each other. Principal component analysis can optimally simplify and synthesize high-dimensional variable systems, so as to objectively determine the weight of each indicator and avoid subjectivity. Therefore, it has been applied to research fields such as land resource development, environmental vulnerability and

environmental degradation. Compared with the quantitative evaluation methods of environmental quality such as comprehensive index method, fuzzy comprehensive evaluation method, neural network and grey clustering method, the principal component analysis method has the advantages of reducing the loss of original data information, simplifying the data structure and avoiding subjectivity, and has been applied in the research of soil environmental pollutant evaluation. The heavy metals in soil mainly come from soil parent materials and human activities, so the pollution sources of heavy metals in soil can be effectively identified by principal component analysis.

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