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Research on Mathematical Model of Soil Pollution Assessment Based on CNKI Database

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Abstract

Soil pollution not only affects the quality of soil environment, but also poses an unpredictable threat to human health. Objective and reasonable evaluation of soil pollution status is of great significance to improve the status of soil pollution and ensure human health and safety. In order to understand some main methods of soil pollution assessment at present, this paper analyzes based on CNKI data, summarizes some commonly used soil pollution assessment methods, and analyzes the advantages, disadvantages and application scope of various methods, so as to provide accurate and objective soil pollution assessment. Evaluation provides reference.

Keywords

Soil pollution, evaluation methods, literature statistics.

1. Introduction

In the process of modern industrial development and urbanization, people over-pursue economic benefits and ignore environmental problems, resulting in a series of soil pollution problems. For example, the problem of soil pollution caused by the wanton discharge of industrial waste gas, waste water and waste residue, improper disposal of domestic waste, sewage irrigation and application of fertilizers containing heavy metals is becoming more and more serious. Soil pollution has become the most harmful environmental problem in China and even in the world. According to the survey results of soil pollution, the excess rate of soil pollutants in China is about 16.1%, and the pollutants are mainly heavy metal pollution, followed by organic pollution. Moreover, in recent years, there have been incidents of harm to human health caused by soil pollution all over the country. Health risk assessment can evaluate the degree of harm of soil pollution to human health from the perspective of the harm of pollution to human body. The results are easier for the public to understand and accept than other methods. Moreover, the evaluation of soil pollution degree is of great significance to the protection of soil environment and human health. Based on CNKI database, this paper statistically analyzes some common methods of soil pollution evaluation in recent years, introduces some main methods, analyzes their advantages, disadvantages and application scope, and provides support for soil pollution remediation and treatment.

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2. Literature statistics of soil pollution assessment methods

In CNKI database, 706 documents were retrieved with the themes of "soil pollution" and "assessment method". Figure 1 shows the distribution characteristics of literature in different years. It can be seen that from 2000 to 2020, the literature of related research has been showing an increasing state, indicating that the study of soil pollution assessment has always been a hot issue in environmental science. The growth was relatively fast from 2000 to 2010 and slowed after 2010.

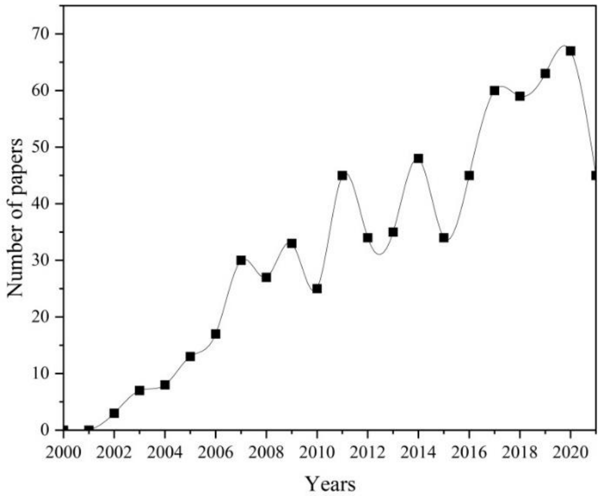

Figure 1. Distribution characteristics of papers in different years.

3. Soil pollution assessment method

3.1. One-factor exponential method

The single-factor pollution index method uses the background value of the elements in the soil as the evaluation criterion to evaluate the pollution degree of each element. The calculation method is shown in the formula: $C_f^i = C_s^i / C_n^i$. In the formula, C_f^i represents the pollution index of the element, C_s^i represents the measured concentration of the element ($mg \cdot kg^{-1}$), and C_n^i indicates the relevant element evaluation standard ($mg \cdot kg^{-1}$) [1]. The larger the value of C_f^i, the more serious the pollution. The single-factor quality index method only compares and evaluates a single pollution factor with the standard value, and cannot reflect the difference between the toxicity of the pollution factor to the human body. Therefore, it usually needs to be used in conjunction with other evaluation methods.

3.2. Nemero Comprehensive Pollution Index

The Nemerow comprehensive pollution index is one of the most commonly used methods to calculate the comprehensive pollution index at home and abroad. This method is a weighted multi-factor environmental quality index that takes into account extreme values or outstanding maximum values, and can more comprehensively reflect the synergistic effect of various pollutants, so as to more accurately evaluate the pollution degree of various environmental elements [2]. Its calculation method is as follows:

$$P_n = \sqrt{0.5 \times [\max(P_i)^2 + \mathrm{ave}(P_i)^2]} \quad (1)$$

P_n is the Nemerow comprehensive pollution index, $\max(P_i)$ represents the maximum value of the single-factor pollution index of heavy metals, and $\mathrm{ave}(P_i)$ represents the average value of the single-factor pollution index of each heavy metal. The pollution index classification standard is shown in Table 1. Up to now, the method has been applied to various environments

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such as river water, lake sediment and soil. The calculation process of this method is simple, the physical concept is clear, and the operability is strong. However, there are some problems in the actual application process, so that the evaluation results sometimes cannot accurately and truly reflect the quality of the evaluated environmental elements. There are mainly the following problems: Only the arithmetic mean and maximum value of the single-factor pollution index are considered in the evaluation, and the weight of the maximum value is too high; The weight of the toxicity and harmfulness of the pollution factors participating in the evaluation in the environmental elements of the evaluation is not considered; The influence of the types and quantities of pollution factors participating in the evaluation on the evaluation value is not disclosed [3].

Table 1. Pollution classification of P_n.

P_n	$P_n \le 0.7$	$0.7 < P_n \le 1$	$1 < P_n \le 2$	$2 < P_n \le 3$	$P_n > 3$
Pollution degree	Safe	Precaution	Slight pollution	Moderate pollution	Heavy pollution

3.3. Geoaccumulation index method

The geoaccumulation index method, also known as Muller index, can reflect the natural variation characteristics of the distribution of heavy metals, and can also distinguish the impact of human activities on the environment. It is an important parameter to distinguish the impact of human activities. Its calculation formula is as formula 2 [4]. The geoaccumulation index method has been applied relatively late in China, and it is impossible to compare and analyze the environmental quality between elements or regions. The method combined with cluster analysis can be used for evaluation to make up for the deficiency. When performing single element evaluation, the degree of pollution is measured by the size of I_{Geo}. The larger the I_{Geo}, the more serious the soil pollution. In the comprehensive evaluation, the soil pollution level is generally determined according to the principle of "following the inferior and not the superior", that is, the pollution level corresponding to the item with the largest geological accumulation index of each heavy metal element is determined as the comprehensive pollution level of the sampling point.

$$I_{Geo}=\mathrm{Log}_2\left(\frac{C_i}{kB_i}\right) \tag{2}$$

3.4. Potential ecological risk index method

The potential ecological risk assessment of heavy metal pollution elements in soil has received extensive attention. This assessment method began in the 1980s and provides a powerful tool for environmental management. As an internationally recognized standard method for evaluating potential ecological risks of heavy metals in sediments and soils, it is widely used. It can objectively reflect the potential ecological risks in the study area and give more reasonable evaluation results [5]. The evaluation formula is as follows:

$$C_f^i=\frac{C_s^i}{C_n^i} \tag{3}$$

$$E_r^i=T_r^i\times C_f^i \tag{4}$$

$$RI=\sum_{i=1}^{n} E_r^i \tag{5}$$

Where RI is the potential ecological risk index of multiple heavy metals; E_r^i is the potential ecological risk index of a single heavy metal i; C_f^i is the heavy metal coefficient in soil , the background value of soil heavy metal in Shaanxi Province was used in this study; C_s^i is the measured value of heavy metal i in soil, mg/kg; T_r^i is the content of heavy metal i in the soil

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Toxicity response parameters. However, with the increasing application in practice, some deficiencies were found. For example, the forms of elements in the soil are different, the activities and toxicity of different forms are different, and the contribution to the environment is also different, so that the total amount of risk index cannot be used to obtain an objective evaluation.

3.5. Risk assessment based on human health

The characteristics of human health risk assessment are to link human health status with environmental pollution, and to use risk as an evaluation standard to quantitatively reflect the degree of harm of pollutants to human health, and to estimate the possibility of adverse effects of various pollutants on human health [6]. Therefore, it can determine the pollutants that should be treated with priority and provide a reference for the prevention and control of environmental pollution. The current research results show that different types of pollutants have different exposure routes, and ingestion is one of the most important routes of human exposure. And different groups of people also show different exposure risks. At present, the exposure dose models used in previous studies mostly use foreign parameters, which may not be suitable for the actual situation in various places. We should try our best to conduct sufficient field research and use a series of local parameters to make the evaluation results more realistic.

4. Conclusion

At present, most of the methods evaluate the total content of heavy metals in soil, and there are few studies on the existence of heavy metals in soil, their availability and the possibility of future degradation. The single-factor index method is simple in form and easy to grasp, but it ignores the complexity, gradual change and ambiguity of pollution, and cannot be evaluated comprehensively and objectively. The geoaccumulation index method can reflect the natural distribution characteristics of elements, and is the main method to distinguish human activities from natural factors, but it cannot be compared and analyzed between elements or regional environmental quality, and it is usually combined with cluster analysis to make up for its shortcomings. Although the potential ecological risk index method can comprehensively and accurately evaluate the pollution risk, the determination of the toxicity factor needs to depend on the knowledge level of the evaluators, and the selection is subject to a certain degree. In practical work, due to the antagonism between different forms of heavy metals and different elements, when evaluating, it is necessary to comprehensively consider factors such as the existence state, activity, degradation degree, soil utilization efficiency and crop type of polluting elements. In the future, with the continuous development and improvement of big data technology, risk assessment based on human health and assessment methods based on GIS and geostatistics will be the trend of soil pollution assessment in the future.

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