Two kinds of evaluation models of heavy metal pollution based on Matlab-FIS-sugeno of Tongling City

Yinling Jiang[1], Yongkang Chen[2]

[1]Department of Electrical Information Engineering, Northeast Petroleum University, Daqing, 163318, China

[2]Daqing Water Affairs Bureau, Daqing, Heilongjiang, China

Abstract

Tongling City, Anhui Province, is the main mining city in China, the environment pollution is more and more serious. The exploitation and smelting of copper, gold and polymetallic deposits, has become an important pollution source of heavy metal pollution in soil environment in Tongling. Heavy metal pollution is an important factor to destroy the soil environment, and directly or indirectly harm to human health. In this paper, two methods are used to evaluate soil heavy metal pollution: The first method is to establish the Nemero index model, the degree of heavy metal pollution in urban soil is analyzed and evaluated, the Nemero comprehensive pollution index shows the pollution level; the second method uses FIS and correlation function of MATLAB software, combined with fuzzy comprehensive evaluation method to establish the membership function of Hg and other 6 kinds of soil heavy metal pollution factors. Through the normalization of Maflab-FIS-sugeno model weights, make the membership function adapt fuzzy comprehensive evaluation of weighted fuzzy operator. Thus, we establish the fuzzy comprehensive evaluation model of heavy metal pollution in soil based on Matlab-FIS-sugeno. Respectively, using these two models to evaluate the heavy metal pollution in agricultural soils of Tongling area, the results were consistent with the actual situation.

Keywords

soil heavy metal pollution; Matlab; fuzzy comprehensive evaluation; Nemerow comprehensive pollution index.

1. Introduction

Tongling city , located in the southern part of Anhui Province and the south bank of the Yangtze River which has favorable conditions for mineralization, is known as non-ferrous metal copper. Tongling area has found 115 orefields , including large, medium and small ore deposit. The mineral resources are mainly copper, but also with mercury, cadmium, chromium, lead, arsenic, zinc and other heavy metal elements. With the development of mineral resources which lead to the destruction of natural resources [1-2], the soil heavy metal pollution become increasingly serious environmental problems, soil pollution of heavy metals enriched in the human body through the food chain and finally damage human health. The pollution of heavy metals in soil is often contaminated, and the effect of different metal elements on the ecological environment is different. Traditional single factor evaluation of the pollution degree evaluation method can only give the monitoring points of a heavy metal factor is excessive and over standard rate,but can not give quantitative soil environmental quality comprehensive evaluation results. Therefore, in this paper, we use the Nemerow comprehensive pollution index method and fuzzy comprehensive evaluation method to study heavy

metals in the soil, and construct the evaluation model of Tongling area. We analyze and compare the results, and the results are in line with the actual situation [3-4].

2. Nemerow comprehensive pollution index evaluation method

Nemero index method is one of the most commonly used methods for the calculation of comprehensive pollution index, which is a new comprehensive evaluation index based on the theory of discrete mathematics. First, we should determine the background value of the soil, that is the chemical elements and compounds content which are not affected by human pollution in the natural environment . Factors affecting soil background values are very complex, including tens of thousands of years of human activities combined effects, the influence oforganic matter content and so on. Therefore, soil background values are a range of values, rather than a determined value. After investigation, the soil environmental background values in Tongling area are shown in Table 1.

Table 1 Soil environmental background values in Tongling (mg/kg)

Hg	Cd	As	Pb	Cu	Zn
0.05	0.09	12.44	47.81	32.15	85.58

Meanwhile, after investigation we have obtained the measured values of heavy metals in soil in Tongling ,which is shown in Table 2.

Table 2 Heavy metal content in soil (mg/kg)

Sampling point	Hg	Cd	As	Pb	Cu	Zn
1	0.071	1.22	16.9	81.2	76	136.5
2	0.076	0.139	11.2	23.2	28.3	58.8
3	0.071	1.12	21.5	74.3	81	136
4	0.108	0.674	14.9	91.3	76.9	188.6
5	0.096	1.11	17.9	80.5	71.5	195.5

First, by formula (1), the different points of the different heavy metals of the single factor Nemero index were calculated:

$$P_i = C_i / S_i \tag{1}$$

In the formula, C_i is the measured value of single heavy metal content, S_i is the soil environmental background value. After calculation, the single factor Nemero index of different elements of 1-5 sampling points are shown in Table 3.

Table 3 Single factor Nemero index of heavy metals in soil (mg/kg)

Sampling point	Hg	Cd	As	Pb	Cu	Zn
1	1.42	13.5556	1.3585	1.6987	2.3385	1.5950
2	1.52	1.5444	0.9003	0.4853	0.8677	0.6871
3	1.42	12.4444	1.7283	1.5541	2.5194	1.8892
4	2.16	7.4889	1.9775	1.9096	2.3919	2.2038
5	1.92	12.3333	1.4389	1.6837	2.2	2.2844

As the single factor Nemero index can not accurately display the degree of land pollution, so we use the comprehensive Nemero pollution index to evaluate:

$$P_{iavg} = \frac{\sum_{i=1}^{n} w_i P_i}{\sum_{i=1}^{n} w_i} \tag{2}$$

$$P_i = \sqrt{\frac{P_{iavg}^2 + P_{i\max}^2}{2}} \tag{3}$$

In the formula, P_{iavg} is the weighted average of the single factor index; $P_{i\max}$ is the maximum value of single factor Nemero index; w_i is the weight ; P_i is the Nemero comprehensive evaluation index.

The single factor index obtained by average value is not accurate, so the average value can be improved by using the weighted average. The weights are classified as shown in Table 4.

Table 4 Weight value of heavy metal pollution elements

Hg	Cd	As	Pb	Cu	Zn
3	3	3	3	2	2

After calculation, the comprehensive Nemero evaluation index of the 1-5 sampling points is shown in Table 5.

Table 5 Nemero comprehensive pollution index of different sampling points

Sampling point	1	2	3	4	5
Nemero index	9.9688	1.2978	9.1937	5.7326	9.1294

According to the evaluation criteria of Nemero's comprehensive pollution index, the sampling point (2) is light pollution, and the other sampling points are heavy pollution, the evaluation results are consistent with the actual results.

3. Fuzzy comprehensive evaluation method

With the deepening of environmental quality assessment, the variables need to study are increasing and becoming more and more complex. There are not only the determined change rules ,but also the random change rules. The accuracy and fuzzy of the environmental quality, determination and uncertainty are all characteristic of quantity. So we use fuzzy comprehensive evaluation method to evaluate the degree of heavy metal pollution in soil. The so-called fuzzy comprehensive evaluation method is the application of fuzzy transformation principle and maximum membership principle, it considers the influence of the factors related to the things to be evaluated. Therefore, the fuzzy evaluation model of farmland soil in Tongling mining area is proposed by using the FIS tool in MATLAB software, and the model is applied to evaluate the heavy metal pollution in farmland soil in Tongling mining area [5].

According to the grading standard, using MATLAB-FIS membership function editor to generate the corresponding membership function. In this paper, we use the semi trapezoidal function and linear trigonometric function to generate the membership functions. The results are shown in Figure 1

Finally, we take sample point 1 as an example, the fuzzy relational matrix is obtained:

$$R=\begin{bmatrix} 0.4167 & 0.5833 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.8191 & 0.1910 \\ 0 & 0 & 0.81 & 0.19 & 0 \\ 0 & 0 & 0.8528 & 0.156 & 0 \\ 0 & 0 & 0.4182 & 0.5636 & 0 \\ 0 & 0 & 0.856 & 0.144 & 0 \end{bmatrix} \tag{4}$$

The weight sets of various metal contaminants of the sample point 1 has been shown in Table 8. We can get：

$$\begin{aligned} W &= \{W_1 \ W_2 \ W_3 \ W_4 \ W_5 \ W_6\} \\ &= \{0.0343 \ 0.3421 \ 0.2169 \ 0.1115 \ 0.1497 \ 0.1455\} \end{aligned} \tag{5}$$

In this way, the fuzzy comprehensive evaluation vector of sample point 1 is:

$$B_1 = W \times R = \{0.0143 \ 0.02 \ 0.4579 \ 0.4408 \ 0.0653\} \tag{6}$$

The evaluation results obtained by MATLAB simulation are shown in Figure 2.

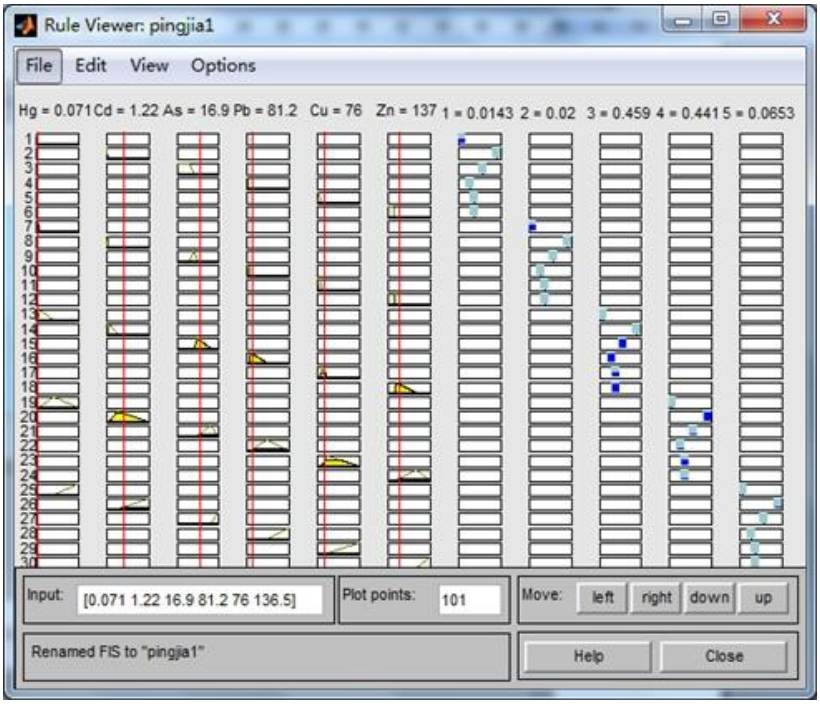

Figure 1 Rule observer for sampling point 1

It can be seen in Figure 1, the sampling point one's comprehensive evaluation vector is $B_1=\{b_1 b_2 b_3 b_4 b_5\}=\{0.0143\ 0.02\ 0.459\ 0.4415\ 0.0653\}$. The results are consistent with the results of the comprehensive evaluation, which prove that the simulation results are reliable.

Among them, $b_3 = 0.459 > b_4 = 0.4415 > b_5 = 0.0653 > b_2 = 0.02 > b_1 = 0.0143$, According to the principle of maximum membership degree, the comprehensive evaluation of soil sampling point 1 is level 3, which is light pollution. Figure 2 longitudinal dark part followed by Hg, CD, as, Hg, Pb, Cu, Zn ,totally six kinds of heavy metal elements at all levels of the corresponding membership, which 1 ~ 6 said level 1 membership degree, 7 to 12 said level 2 membership degree and 13 ~ 18 said level 3 membership degree, 19 to 24 said level 4 membership degree, 25 ~ 30 said level 5 membership degree .

4. Conclusion

Nemero index method has highlighted the impact of the largest pollution on environmental quality. This way avoid the phenomenon of average value weaken metal pollution weight element occurred. However, it is too high to highlight the impact of the largest pollution index of pollutants on the environment, so that the evaluation of environmental quality is not enough. But its calculation is small, the method is simple to understand, so it is widely recognized. The fuzzy comprehensive evaluation method, which can be seen in the results of the evaluation, can reflect the actual soil pollution risk in the study area. In a certain extent can effectively overcome the phenomenon of evaluation results' inaccurate caused by abnormality of a certain or some heavy metals pollution. Meanwhile, it can reduce the phenomenon of evaluation results does not conform to the actual caused by measurement error. Therefore, this method can be used as an effective method to evaluate the pollution degree of heavy metals in the soil. In this paper, we use matlab-fis toolbox to simplify large amount of calculation, and the accuracy is greatly improved, but when this method in the face of a large number of data, computing was still very tedious. At the same time, the model has not yet been fixed and don't have an unified standard, this need in-depth study.

References

[1]Yang Wei, Li Qiqiang, 2004, "Particle swarm optimization algorithm", Journal of China engineering science.

[2]Liu Huidong, Liu Tianqi, 2004, "Status quo and Prospect of power system state estimation", Electric power automation equipment, vol.24, No.12, pp 73-77.

[3]Huang Yanquan, 2004, "Study on some problems of power system state estimation", Southwest Jiao Tong University.

[4]Dahlstrom C.D.A, 1969, "Balanced Cross Sections &Canadian Journal of Earth Sciences", AAPG bull, no.6, pp 743-757.

[5]Morrow N R., 1970, "Physics and Thermodynamics of Capillary Action in Porous Media", Industrial and engineering chemistry, no.2, pp 32-56.