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Research of Heavy Metals Pollution Soil Risk Evaluation by Means of Engineering in Gold Mining Area, Tongguan, China

Gang Li[1, 2, 3, 4, *], Nan Lu[1, 2, 3, 4], Yang Wei[1, 2, 3, 4] and Daiwen Zhu[1, 2, 3, 4]

[1]Shaanxi Provincial Land and Engineering Construction Group Co, Ltd. Xi'an 710075, China
[2]Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co, Ltd. Xi'an 710075, China
[3]Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Land and Resources of China, Xi'an 710075, China
[4]Shaanxi Provincial Land Consolidation Engineering Technology Research Center. Xi'an 710075, China

*Corresponding author e-mail: 454923994@qq.com

Abstract. As the core technology of soil heavy metal remediation and management in Tongguan gold mining area, only the objective and comprehensive evaluation of its governance effect can we promote this technology in Tongguan gold mining area and other similar areas Applications provide solid and reliable data support and scientific basis. In this study, samples were set up in the project area of Tongguan gold mining area. Primary data of the control area were obtained through sample collection and laboratory sample analysis. Soil samples of Tongguan gold mine project area were analyzed by single pollution index method and Nemero integrated pollution index The results showed that all kinds of metal elements in tillage soil have reached the level of cleanliness and the soil quality belongs to the first grade safety status, which provides the data support and scientific basis for the popularization and application of the project.

1. Introduction

In recent years, Soil around the mining area and plant pollutions received more and more attention both at home and abroad [1-7]. Mining, Tailings and Smelting heavy metals et. al. which Contain higher concentrations of toxic heavy metals are the mainly sources of heavy metals pollution, and these would bring serious threat to the soil and plants around the Mining area. Because of kinds of heavy metals in soil around mining zones, these heavy metals would bring more serious harms to the ecology and environment when they precipitate and fixate in the soil and transfer in nature cycle [8].

Through on-site survey and sampling analysis of Tongguan area, we found that the area of pollution soil in the mining zone is larger than non-pollution area. The mainly pollution elements include Hg, Pb, Cd, Cu and Zn, of which Hg-type pollution accounted for 67.80%. The tailings slag and cyanide residue which piled freely in the farming-filed would not only bring serious pollution to the farm land, water and plants, but also take up a lot of land resources. As a direct result, heavy metals in crops were exceeded, the farmer's income was general poor [9].

To solve the problem of soil heavy metal pollution, we should focus on the study that the behavior of the metal elements soil ecology chemistry and repair technology, especially the research of plants and microorganisms repair technology and plants-microorganisms joint repair technology [10-13]. To solve complex polluted soil, we shall choose the technology according to the property of the polluted elements, the condition of the soil, the degree of pollution and the cost of the engineering. The project isolated management of the polluted soil in the mining zone at Tongguan County, Shaanxi province which solve the soil pollution problem mainly by ways of storage and isolation, and eliminate the harms of heavy metals to the environment and ecology (fig. 1). The equipment like rollers, forklifts, excavators and mixers we need in the project are simple and easy to get, and the materials are as well.

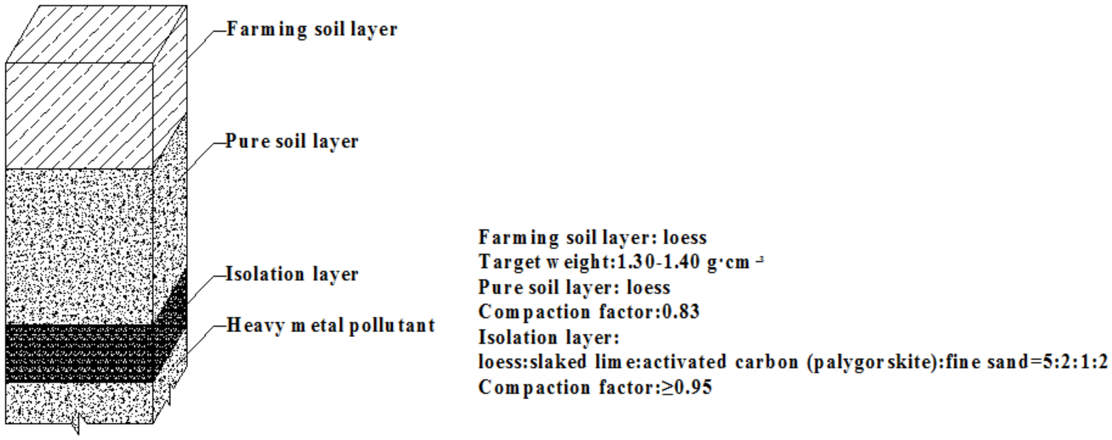

Figure 1. The section figure of the treatment project to the pollution soil.

As the key technical means for the restoration and treatment of heavy metals in soils in Tongguan gold mining area, only the objective and comprehensive follow-up study and evaluation of the treatment effects can be carried out for this technology in the Tongguan gold mining area and even Other similar areas to promote the use of guidance. In order to monitor the effect of project management, this study set a sampling point in the project area of Tongguan gold mining area, obtained the first-hand data after the treatment through the sample collection and the laboratory analysis of the sample, and through the single pollution index method and Nemerow comprehensive pollution index Law to evaluate the comprehensive effect of heavy metals in soils of Tongguan gold mine project area and provide practical and scientific data support and scientific basis for project popularization and application.

2. Materials and Methods

2.1. Description of the research area

Tongguan County is located at the eastern end of the Guanzhong Plain and covers the western part bordered by Tongguan County in Shaanxi Province and Lingong City in Henan Province. The geographical location lies between 110 ° 08'00 "-110 ° 29'00" east longitude and north latitude 34 ° 23'00 "-34 ° 38'00", an area of about 445 km2. The topography of Tongguan County is high in the south and low in the north, from the Qinling Mountains to the Yellow River and the Weihe River valleys, the terrain gradually decreases, and the landscape types are diverse and the landscape contrasts sharply. Tongguan County is a continental monsoon arid climate with warm temperate continental rainfall in the same season, and has the characteristics of larger temperature difference, less precipitation, stronger evaporation and dry climate. According to the local meteorological department data, the annual average temperature of 13.0 ℃, the coldest January, the average temperature of -1.6 ℃, extreme low temperature -18.2 ℃. The hottest July, the average temperature of 26.1 ℃, the extreme maximum temperature of

42.7 ℃, the difference between the east and the west is not obvious, large temperature difference between day and night. In the area, the high gully is deep, the wind is large, and the soil evaporates strongly. The annual evaporation is 1193.6 mm, and the precipitation is 52.41% of the evaporation. Four seasons windy, the annual average of more than 8 gale 15.12 times [14]. The average annual rainfall of 587.4 mm, the maximum rainfall of 958.6 mm, the minimum rainfall of 319.1 mm, significant differences between north and south, decreasing from north to south. From south to north can be roughly divided into brown soil, cinnamon, sand clay, clay, soil five kinds of soil. The project research area is located in Yao Shang Village, Taiyao Town, Tongguan County, 20 km away from Tongguan County. The main pollution source is tailings. Most of the tailings are piled randomly along the river courses and bank slopes, and are restored to cultivated land after isolation and treatment by soil engineering. The main planting Corn, peanuts and masson pine.

2.2. Sample collection

In accordance with the requirements of HJ/T 166-2004 "In September 2017, six sample plots were set up in Yaoxintang village, Taiyao town, Tongguan county to collect 0-20 cm, 20-40 cm, 40-60 cm and 60-80 cm soil respectively. According to Technical Specifications for Soil Environmental Monitoring, Requirements, in order to make the sample representative, surface soil or tailings sampling points in a main, as a fixed location, within the range of 5 m "plum sampling method", 2 to 3 subsamples of a sample, Quads are used to discard excess samples. Each sample is made up of 5 sample mixes and weighs 1 kg for a total of 21 samples. The collected samples were placed in the room to dry naturally, remove debris, sand, debris and other debris.

The soil samples were air-dried in the laboratory to remove debris and ground through 0.149 mm nylon mesh, and stored to be measured [15, 16]. The soil total Pb-Zn was determined according to GB / T 17141-1997, "Determination of Lead and Cadmium in Soil Quality: Graphite Furnace Atomic Absorption Spectrometry" Determination of chromium: Flame atomic absorption spectrophotometry "(HJ 491-2009)," Determination of soil quality nickel: Flame atomic absorption spectrophotometry "(GB / T 17139-1997)," Determination of soil quality of copper, zinc: Flame atomic absorption spectrophotometry "(GB / T 17138-1997)," Determination of total mercury in soil quality, total arsenic, total lead by atomic fluorescence spectrometry Part 1: Determination of total mercury in soil "(GB / T 22105.1-2008), "Determination of total mercury, total arsenic and total lead in soil quality: atomic fluorescence spectrometry Part 2: Determination of total arsenic in soil" (GB / T 22105.2-2008).

2.3. Descriptive statistics of the data

The national soil environmental quality standard (GB 15618-1995) divides the soil environmental quality into three grades [17], as shown in Table 1. In this study, we evaluated the soil remediation effects of compound polluted soil engineering isolation and control area in Tongguan mining area with the natural background values of the soil of the second grade of National Soil Environmental Quality Standard. The evaluation indexes are As, Ni, Pb, Cd, Cr, Cu, Zn, Hg. The assessment of soil heavy metal pollution with reference to soil pollution grading standards (Table 2).

Table 1. National Soil Environmental Quality Standard.(GB 15618-1995)

Level	1st	2nd			3rd
pH	Background	<6.5	6.5~7.5	>7.5	>6.5
As	15	40	30	25	40
Ni	40	40	50	60	200
Pb	35	250	300	350	500
Cd	0.20	0.30	0.30	0.60	1.0
Cr	90	150	200	250	300
Cu	35	50	100	100	400
Zn	100	200	250	300	500
Hg	0.15	0.30	0.50	1.0	1.5

Table 2. Soil Environmental Quality Rating Scale.

Pollution index	Pollution degree	Pollution level	Grade
Pn≤0.7	Safety	Clean	I
0.7＜Pn≤1	Alertly	Still clean	II
1＜Pn≤2	Light pollution	Soil contaminants exceed their background and crops begin to be contaminated	III
2＜Pn≤3	Moderately polluted	Soil and crops are moderately contaminated	IV
Pn＞3	Severe pollution	Soil pollution has been quite serious	V

2.4. *Evaluation method and standard of heavy metal pollution*
In this study, single pollution index method and Nemerow comprehensive pollution index method to evaluate the effect of heavy metal restoration. Among them, the single factor pollution index evaluation method is mainly used to evaluate the cumulative level of soil heavy metal pollution, Nemerow index method for evaluating the degree of soil comprehensive pollution of heavy metals.

The one-factor pollution index method is used to estimate the pollution index of a single pollutant in soils. The formula is (1).

$$P_{ij} = \frac{c_{ij}}{s_{ij}} \tag{1}$$

Where j is the environmental quality index of j samples in soil samples from the Yellow River beach; i is the measured content of j samples (mg·kg-1); i is the evaluation standard of pollutants (mg·kg-1). The single factor pollution index of soil heavy metal pollution was evaluated according to the soil quality environmental standards (Table 1).

NL Nemerow integrated pollution index method, the formula (2) is:

$$P = \sqrt{\frac{(P_i)^2+(P_{imax})^2}{2}} \tag{2}$$

In the formula, it is Nemero's comprehensive pollution index; It is the ratio of the measured content of heavy metal i to the reference value of the evaluation (with different evaluation reference background value); It is the maximum value of the largest pollution index of each heavy metal. It not only considers the average pollution level of various pollutants, but also reflects the existence of serious pollutants and environmental hazards in the pollution.

2.5. *Data processing*
Using Microsoft Excel 2010 for data processing, Origin 8.5 for drawing.

3. Results

3.1. *Descriptive statistics of soil heavy metal content*
The statistical analysis of the contents of As, Ni, Pb, Cd, Cr, Cu, Zn and Hg in the Yao village of Taiyao town in Tongguan county (Table 3) shows that in terms of As distribution, the maximum As content The value is 13.51 mg kg-1 in the depth soil of 0-20 cm, which is less than the first-grade standard of the national soil environmental quality standard, indicating that As content in the soil in the area is not excessive and will not pollute the soil. The average content of Hg in the soil of 40-60 cm was 0.88 mg kg-1, which accorded with the national soil environmental quality standard and had no harm to the cultivation of agricultural products. With the increase of soil depth, the content of Zn in soil increased.

The average content of Zn in soil of 40-60 cm was 84.2 mg kg-1, which was less than the first grade standard of national soil environmental quality standard, which had no harm to soil environment. The maximum content of Cu in soil appeared at 40-60 cm, the average value was 34.5 mg kg-1, which was less than the first-grade standard of national soil environmental quality standard, which was not harmful to the cultivation of agricultural products. The maximum Pb element content at 40-60 cm reached 96.6 mg kg-1, which met the second-grade standard of national soil environmental quality standard. The content of Cd in 0-60 cm soil was less than 0.6 mg kg-1 in this area, the content of Cr in soil of Grade 2 reached the national soil environmental quality standard was less than 90 mg kg-1, and the content of Ni in soil was less than 40 mg kg-1, less than the national standard of soil environmental quality standards, indicating that the content of soil Cr and Ni are not exceeded, will not cause pollution to the soil.

Table 3. Descriptive Statistics of Soil Heavy Metal Content

Soil depth	Sample types	As	Hg	Zn	Cu	Pb	Cd	Cr	Ni
0~20 cm	Maximum	13.51	0.52	80.8	28.3	72.9	0.408	69.4	29.6
	Minimum	9.70	0.18	59.7	22.8	37.2	0.151	38.1	26.2
	Average value	11.46	0.39	67.8	26.1	49.3	0.267	55.9	27.7
	Standard deviation	1.84	0.12	9.6	2.4	13.9	0.103	13.6	1.4
	Coefficient of variation	16.06	31.44	14.2	9.1	28.2	38.445	24.4	5.0
20~40 cm	Maximum	13.17	0.47	105.3	26.1	50.2	0.314	61.9	28.9
	Minimum	9.57	0.05	55.6	20.1	21.1	0.127	40.3	25.5
	Average value	11.66	0.25	70.3	22.6	33.1	0.187	52.2	27.3
	Standard deviation	1.52	0.15	21.1	2.5	11.2	0.079	9.3	1.4
	Coefficient of variation	13.06	61.10	30.0	10.9	33.8	42.360	17.7	5.3
40~60 cm	Maximum	13.15	1.66	133.6	43.3	184.0	0.419	69.0	31.3
	Minimum	9.17	0.38	66.4	29.0	48.4	0.158	40.5	26.7
	Average value	11.05	0.88	84.2	34.5	96.6	0.276	54.9	29.2
	Standard deviation	2.01	0.50	25.5	6.2	49.7	0.111	11.6	2.1
	Coefficient of variation	18.16	57.26	30.3	17.9	51.4	40.231	21.2	7.1
60~80 cm	Maximum	14.75	2.00	258.3	81.0	409.2	2.210	65.9	34.7
	Minimum	11.23	0.53	145.1	32.1	86.6	0.611	40.6	28.4
	Average value	11.62	10.52	125.8	41.0	163.4	7.575	42.9	21.8
	Standard deviation	1.78	0.83	56.9	26.5	162.9	0.871	13.9	3.4
	Coefficient of variation	15.31	7.93	45.2	64.7	99.7	11.502	32.4	15.4

3.2. Single pollution element evaluation

According to the single-factor pollution index method, all heavy metal elements in the soil layer (0-40 cm) of tillage layer reached the level of cleanliness, and all the heavy metal elements in the soil layer (0-60 cm) Above, basically meet the requirements of soil environmental quality standards (Table 4).

Table 4. Pollution Status of Soil Heavy Metal Sample Single Factor /%

Soil depth	Element	I Safty	II Alertly	III Light pollution	IV Moderately polluted	V Severe pollution
0~20 cm	As	100%	/	/	/	/
	Hg	100%	/	/	/	/
	Zn	100%	/	/	/	/
	Cu	100%	/	/	/	/
	Pb	100%	/	/	/	/
	Cd	100%	/	/	/	/
	Cr	100%	/	/	/	/
	Ni	100%	/	/	/	/
20~40 cm	As	100%	/	/	/	/
	Hg	100%	/	/	/	/
	Zn	100%	/	/	/	/
	Cu	100%	/	/	/	/
	Pb	100%	/	/	/	/
	Cd	100%	/	/	/	/
	Cr	100%	/	/	/	/
	Ni	100%	/	/	/	/
40~60 cm	As	100%	/	/	/	/
	Hg	66.67%	33.33%	/	/	/
	Zn	100%	/	/	/	/
	Cu	100%	/	/	/	/
	Pb	100%	/	/	/	/
	Cd	100%	/	/	/	/
	Cr	100%	/	/	/	/
	Ni	100%	/	/	/	/

3.3. Nemerow pollution index act

According to the State environmental protection agency soil environmental quality standard (GB15618-1995) and soil pollution grading standards for evaluation. Nemero pollution index method was used. The results showed that the comprehensive pollution index of soil in tillage layer (0 -40 cm) were 0.529 and 0.418 respectively (Table 5). Refer to Table 2, both of them are less than 0.7, the soil environmental quality belongs to class I safety state, The plant and the environment is basically not cause pollution and harm.

Table 5. Soil heavy metal pollution index

Soil depth	Element	Single pollution index method			Integrated pollution index	Degree of pollution
		Average value	Minimum value	Maximum value		
0~20 cm	As	0.458	0.388	0.540	0.529	Safty
	Hg	0.336	0.180	0.475		
	Zn	0.226	0.199	0.269		
	Cu	0.261	0.228	0.283		
	Pb	0.141	0.106	0.208		
	Cd	0.445	0.252	0.681		
	Cr	0.160	0.109	0.198		
	Ni	0.462	0.437	0.493		
20~40 cm	As	0.466	0.383	0.527	0.418	Safty
	Hg	0.213	0.152	0.317		
	Zn	0.234	0.185	0.351		
	Cu	0.226	0.201	0.261		
	Pb	0.094	0.060	0.143		
	Cd	0.311	0.212	0.523		
	Cr	0.149	0.115	0.177		
	Ni	0.455	0.425	0.481		
40~60 cm	As	0.442	0.367	0.526	0.952	Alertly
	Hg	0.881	0.482	1.280		
	Zn	0.281	0.221	0.445		
	Cu	0.345	0.290	0.433		
	Pb	0.276	0.138	0.526		
	Cd	0.459	0.263	0.699		
	Cr	0.157	0.116	0.197		
	Ni	0.487	0.445	0.521		

4. Conclusion

Through the descriptive statistical analysis of soil after the treatment in the kiln Shangcun project area of Taiyao town, Tongguan county, the analysis and evaluation of the single pollution elements and the Nemero Index method, we can see that the soil in the tillage soil can reach the national soil Environmental quality standards above the second-level standards, soil environment in general I-level safe state, the basic will not cause harm to soil and plants and pollution, can be used for planting crops such as corn, peanuts, but the main areas such as atmospheric deposition Impact of the process on crops.

After remediation, there is no source of pollution such as solid waste dumping and sewage irrigation. However, the use of agricultural materials has a long-term effect on the accumulation of heavy metals in the soil. Therefore, the atmospheric deposition of pollutants and the isolation of heavy metals containing heavy metals Tailings have become an important source of heavy metals in soils and vegetable sources of heavy metals [18-21]. In order to evaluate the contribution of atmospheric deposition of pollutants to heavy metal pollution, the heavy metals in the reconstructed soil profile should be monitored. The heavy metals in the crop should also be monitored.

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