Assessment of Soil Environmental Quality in Huangguoshu Waterfalls Scenic Area

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Abstract. This paper concentrates on five major heavy metal pollutants as soil environmental quality evaluation factors, respectively Lead (Pb), Cadmium (Cd), Mercury (Hg), Arsenic (As), Chromium (Cr), based on the National Soil Environmental Quality Standards (GB15618 - 1995), we used single factor index evaluation model of soil environmental quality and comprehensive index evaluation model to analyze surface soil environmental quality in the Huangguoshu Waterfalls scenic area. Based on surface soil analysis, our results showed that the individual contamination index, Pb, Hg, As and Cr in the Huangguoshu Waterfalls scenic area met class 1 according to requirements of National Soil Environmental Quality Standards, which indicated that Pb, Hg, As and Cr were not main heavy metal pollutants in this area, but the individual contamination index of Cd in soil was seriously exceeded National Soil Environmental Quality Standards’ requirement. Soil environmental quality in Shitouzhai, Luoshitan, Langgong Hongyan Power Plant have exceeded the requirement of National Soil Environmental Quality Standards "0.7<\(P_c\)≤1.0" (Alert Level), these soils had been slightly polluted; the classification of soil environmental quality assessment in Longgong downstream area was above "Alert Level", it indicated that soil in this area was not polluted. Above all, relevant measures for soil remediation are put forward.

1. Introduction
Soil is an important part of the environment, soil environmental quality is directly

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affected by contents of each element. The difference of soil environmental quality has significant impact on agricultural production, soil environmental quality assessment is the premise to carry out agricultural activities.

Soil quality assessment is the main research topic in both China and other countries, in 1989 Power and Myers proposed soil environmental quality assessment was based on nutrients availability of soil supplying to maintain crop growth, including tillage, aggregation, organic matter content, soil depth, infiltration efficiency, water retention ability, soil acidity and alkalinity as well as soil composition. Yan Du et.al proposed that heavy metal pollution in soils were mainly caused by unreasonably anthropogenic activities in Advances in Assessment Methods of Soil Environmental Quality, excessive soil exploits make the contents of heavy metal were higher than the National Soil Environmental Quality Standards’ requirements, it resulted in the deterioration of ecological environment[1]. Du Yan et.al summed up the methods of soil quality assessment and analyzed advantages and disadvantages of different methods. Based on values of National Soil Environmental Quality Standards, Xinli Xing et.al used index evaluation method, listing 9 elements, respectively As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, F, Se, Cl, P, S as evaluation factors, to assess soil environmental quality in Nanchang[2]. Based on values of National Soil Environmental Quality Standards and soil samples arrayed in S-shape, Ming Hua et.al studied the contents of 6 heavy metal (Cd, Pb, Ni, Zn, Cu, Cr) in evaluated area, they also used index evaluation method to assess soil environmental quality in Uranium mine tailings area[3]. Ling Li et.al also used the index evaluation method to analyze the contents of Pb, Cr, Cd, Hg and As in soils, and assessed the soil environment quality during the process of urbanization in Zhengzhou[4].

In summary, based on requirements of National Soil Environmental Quality Standards and sampling analysis, index evaluation method is one of dominant methods for soil environmental quality assessment.

2. Overview of Study Area

Huangguoshu Waterfalls scenic area is located in the western area of the central Guizhou Plateau, it has typical karst mountain landform. The total area is 163 k㎡, including the Huangguoshu Town and Baishui River Town, the total population is 37,000. The interior of this region has little gradient and surface undulation, topography is relatively flat, which is the boundary area from kegel and turm karst area to karst peak cluster area.

Huangguoshu Waterfalls scenic area is located in the watershed between Yangtze River, Zhu River, it belongs to the North Panjiang River upstream area, it has typically subtropical monsoon climate, rainfall often shows a summer peak. Huangguoshu Waterfalls scenic area is affected by warm and humid airstream from April to October, summer is hot and rainy; Huangguoshu Waterfalls scenic area is influenced by cold and dry airstream, winter is cold and dry, the intensity of solar radiation is low, frost-free period is long, humidity is high, climate is characterized by four distinctive seasons. Huangguoshu Waterfalls scenic area is called Spring City compared to cities at the same latitude.

3. Sampling and Analysis of Soil Samples

In order to fully understand the soil environment of Huangguoshu Waterfalls scenic area, especially to have a better understanding of the soil environment in both upstream and downstream core areas, we collected soil samples along the Baishui river then tested samples, analyzed date and made conclusions.

3.1. Sampling Points Selection

In order to ensure soil samples are representative, we took Soil Monitoring Technology Standard (HJ/T166 - 2004), arrayed soil samples in S-shape and numbered them from 1 to 22. We took soil samples from 8 places, respectively shore sides area of Shitouzhai River, branches of Shitouzhai River, Baima reservoir in Shitouzhai River, Baima bridge across Shitouzhai River, shore sides area of
Luositan River, Luositan Bridge, downstream area of Longgong, Langgonghongyan power plant.

Before we collected soil samples, geographical coordinates of the sampling points were measured and records were taken, then the basic environmental conditions of the surroundings were photographed for check. The top soils (0cm - 20cm depth) were collected with small shovel then soil samples were mixed, each soil sample weighed 1kg. After we removed gravels, we crushed out soil samples into a thin layer, put soil samples at cool and ventilated places to dry these soil samples. Then soil samples were sieved with nylon sieve (0.149mm), and sieved soil samples were collected in containers with notes, notes were marked with sample number, collection date, collection place, collection depth, sampler signature and other basic information.

3.2. Determine the Evaluation Factors

Based on the National Soil Environmental Quality Standard Value (GB15618 - 1995), we chose 5 dominant heavy metals pollutants which affected growth of animals and plants in karst areas, respectively Lead (Pb), Cadmium (Cd), Mercury (Hg), Arsenic (As), Chromium (Cr), these five elements were listed as soil environmental quality evaluation factors. Soil pH value was also determined.

3.3. Data Analysis

The pH of soil samples from collecting points were determined by Water Immersed- Potentiometric method. Determination of elemental contents Lead (Pb), Cadmium (Cd), Chromium (Cr) in soil used hydrofluoric acid- perchloric acid-nitric acid heating digestion and atomic absorption spectrometry, this method is based on the law of spectrometric absorption. We compared absorbance between control solution and test solution, determined the content of measured elements from test samples. The contents of Mercury (Hg), Arsenic (As) were determined by atomic fluorescence spectrometry, this method is based on the absorption law of spectrophotometry. We analyzed fluorescence intensity of the atomic vapor emitted from test element, test element was measured at a certain wavelength and was excited by the radiation energy, the results are showed in Table 1, pH ranged from 7.18 to 8.28, most soil samples were weakly alkaline.

| Sampling Points | PH  | Pb (mg/kg) | Cd(mg/kg) | Hg(mg/kg) | As(mg/kg) | Cr(mg/kg) |
|-----------------|-----|------------|-----------|-----------|-----------|-----------|
| 1               | 8.21| 45         | 1.22      | 0.26      | 9.13      | 98.9      |
| 2               | 8.2 | 53.7       | 0.74      | 0.86      | 19.26     | 99.6      |
| 3               | 8.13| 43.9       | 0.98      | 0.41      | 8.31      | 115.1     |
| 4               | 8.15| 51.2       | 0.99      | 0.33      | 25.36     | 90.5      |
| 5               | 8.19| 40.7       | 0.75      | 0.3       | 12.45     | 84.5      |
| 6               | 8.22| 30.7       | 0.74      | 0.26      | 13.49     | 66.8      |
| 7               | 7.57| 35.8       | 0.7       | 0.24      | 14.96     | 55.2      |
| 8               | 7.56| 50.5       | 0.72      | 0.28      | 11.28     | 59.5      |
| 9               | 8.25| 33.5       | 0.63      | 0.29      | 6.11      | 54        |
| 10              | 7.33| 38.6       | 0.99      | 0.32      | 6.89      | 54        |
| 11              | 8.13| 40.4       | 0.75      | 0.31      | 8.55      | 114.4     |
| 12              | 8.1 | 38.4       | 0.77      | 0.33      | 8.64      | 113.9     |
| 13              | 8.12| 39.1       | 0.76      | 0.37      | 8.83      | 124.9     |
| 14              | 7.96| 37.9       | 0.75      | 0.35      | 12.42     | 134.5     |
| 15              | 7.66| 38.5       | 0.72      | 0.38      | 2.12      | 129.6     |
| 16              | 7.18| 37         | 0.79      | 0.42      | 6.02      | 110.4     |
| 17              | 8.12| 35.2       | 0.74      | 0.39      | 4.28      | 93.6      |
| 18              | 8.11| 36.1       | 0.77      | 0.41      | 3.24      | 93.8      |
| 19              | 8.16| 31.4       | 0.7       | 0.38      | 4.83      | 86.1      |
| 20              | 8.28| 37.2       | 0.98      | 0.37      | 12.5      | 84.7      |
| 21              | 8.26| 42         | 1.22      | 0.33      | 6.94      | 62.5      |
| 22              | 8.17| 26.6       | 0.74      | 0.36      | 4.58      | 64.1      |
4. Assessment of soil environment quality in Huangguoshu Waterfalls Scenic Area

We chose single factor pollution index evaluation model and comprehensive pollution index model (N.L.Nemerow Model), single factor pollution index evaluation model is relatively simpler to use, comprehensive pollution index model is non-dimensional environmental quality index, we chose this model to analyze impact of various environmental factors on heavy metal pollution.

4.1. Evaluation Criteria

The land use of sampling points is mainly agricultural lands, woodlands and plantain farms, according to the basic requirements of organic agricultural production to the soil in the producing area, and the requirements from governmental agencies on the soil environmental quality of agricultural lands. This paper used two national standards in Class II (Table 2) to evaluate soil environmental quality in Huangguoshu Waterfalls scenic area.

Table 2. Standard Evaluation Values of Pollutants

| #  | Element         | PH<6.5 | PH6.5—7.5 | PH>7.5 | Criterion |
|----|-----------------|--------|-----------|--------|-----------|
| 1  | Lead            | 250    | 300       | 350    | GB        |
| 2  | Cadmium         | 0.3    | 0.3       | 0.6    | GB        |
| 3  | Mercury         | 0.3    | 0.5       | 1      | GB        |
| 4  | Arsenic(dry)    | 40     | 30        | 25     | GB        |
| 5  | Chromium (dry)  | 150    | 200       | 250    | GB        |

Note: the "National Soil Environmental Quality Standard Value" (GB15618 - 1995) is class II evaluation criteria.

4.2. Soil Environmental Quality Assessment Methods and Results

4.2.1. Single Factor Pollution Index Evaluation Model

The evaluation method is based on the comparison between measured in-situ data of soil samples and data of control group from National Soil Environmental Quality Standard Value, we analyzed distribution of elements in soils then understood the pollution level of one specific element. However, this method only evaluates the single element in soil and shows the pollution index ratio of this element in soils, but comprehensive pollution condition in soils cannot be explained. Formula is as follows:

\[ P_m = \frac{C_m}{S_m} \]  

Note: Pm indicates a single factor pollution index; Cm indicates the measured in-situ value of one specific pollutant in the soil; Sm indicates standard value from National Soil Environmental Quality Standard Value.

According to the single factor pollution index, the degree of soil pollution can be divided into 5 degree. When Pm<1 or Pm=1, it indicates that the soil has not been polluted by pollutant M; when the 1<Pm≤2, it indicates the soil is contaminated by pollutant M in micro-degree; when the 2<Pm≤3, it indicates the soil is contaminated by pollutant M in mild-degree; when the 3<Pm≤5, it indicates the soil is contaminated by pollutant M in moderate-degree; when the Pm>5, it indicates the soil is contaminated by pollutant M in strong-degree. As Pm increases, the environmental damage caused by the pollution element in the evaluated area intensifies (Table 3).

Table 3. Pm Evaluation Degree

| Grade | Single Pollution Index | Pollution Evaluation |
|-------|------------------------|----------------------|
| 1     | Pm≤1                   | No                   |
| 2     | 1<Pm≤2                 | Micro-degree         |
| 3     | 2<Pm≤3                 | Mild-degree          |
| 4     | 3<Pm≤5                 | Moderate-degree      |
| 5     | Pm>5                   | Strong-degree        |
Compared the measured in-situ values of soil samples with required values from the national soil environmental quality standard Class Ⅱ (GB15618 – 1995,) we concluded the single pollution index of 5 kinds of heavy metals in the Huangguoshu Waterfalls scenic area (Table 4).

### Table 4. Evaluation Results of Soil Single Factor Index of Heavy Metals

| # | Sampling Point                  | Lead | Cadmium | Mercury | Arsenic | Chromium |
|---|--------------------------------|------|---------|---------|---------|----------|
| 1 | Shore Sides of Shitouzhai River | 0.12 | 2       | 0.26    | 0.37    | 0.4      |
|   | Branches of Shitouzhai River   | 0.15 | 1.25    | 0.86    | 0.77    | 0.4      |
|   | Branches of Shitouzhai River   | 0.12 | 1.63    | 0.41    | 0.33    | 0.46     |
|   | Branches of Shitouzhai River   | 0.14 | 1.65    | 0.33    | 1.01    | 0.36     |
|   | Branches of Shitouzhai River   | 0.11 | 1.25    | 0.3     | 0.5     | 0.33     |
| 2 | Branches of Shitouzhai River   | 0.08 | 1.23    | 0.26    | 0.53    | 0.27     |
|   | Branches of Shitouzhai River   | 0.15 | 1.17    | 0.24    | 0.6     | 0.22     |
|   | Branches of Shitouzhai River   | 0.14 | 1.2     | 0.28    | 0.45    | 0.23     |
|   | Branches of Shitouzhai River   | 0.09 | 1.05    | 0.29    | 0.24    | 0.21     |
| 3 | Baima Reservoir in Shitouzhai River | 0.14 | 1.27    | 0.33    | 0.34    | 0.46     |
|   | Baima Reservoir in Shitouzhai River | 0.11 | 1.25    | 0.31    | 0.34    | 0.46     |
|   | Baima Bridge above Shitouzhai River | 0.11 | 1.25    | 0.35    | 0.5     | 0.53     |
|   | Baima Bridge above Shitouzhai River | 0.12 | 1.28    | 0.33    | 0.34    | 0.46     |
| 4 | Shore sides of Luositan River  | 0.11 | 1.25    | 0.31    | 0.34    | 0.46     |
|   | Shore sides of Luositan River  | 0.12 | 1.28    | 0.33    | 0.34    | 0.46     |
|   | Shore sides of Luositan River  | 0.11 | 1.27    | 0.37    | 0.35    | 0.5      |
|   | Shore sides of Luositan River  | 0.08 | 1.16    | 0.38    | 0.08    | 0.51     |
|   | Shore sides of Luositan River  | 0.12 | 1.25    | 0.35    | 0.5     | 0.53     |
|   | Shore sides of Luositan River  | 0.11 | 1.2     | 0.33    | 0.5     | 0.53     |
|   | Shore sides of Luositan River  | 0.12 | 1.26    | 0.34    | 0.5     | 0.53     |
|   | Shore sides of Luositan River  | 0.11 | 1.26    | 0.35    | 0.5     | 0.53     |
|   | Shore sides of Luositan River  | 0.11 | 1.25    | 0.35    | 0.5     | 0.53     |
| 5 | Luositan Bridge                 | 0.1  | 1.23    | 0.39    | 0.17    | 0.37     |
|   | Luositan Bridge                 | 0.1  | 1.28    | 0.41    | 0.13    | 0.38     |
| 6 | Downstream Area of Longgong     | 0.08 | 1.16    | 0.38    | 0.19    | 0.34     |
|   | Langgonghongyan Power Plant     | 0.1  | 1.63    | 0.37    | 0.5     | 0.33     |
|   | Langgonghongyan Power Plant     | 0.12 | 2.03    | 0.33    | 0.28    | 0.25     |
| 7 | Langgonghongyan Power Plant     | 0.08 | 1.23    | 0.36    | 0.18    | 0.26     |

According to table 5, the following results can be obtained:
(1) In the selected evaluation area, single pollution index of soil heavy metals Lead (Pb), Mercury (Hg), Chromium (Cr) and Arsenic (As), Pm<1, reached the Class Ⅰ based on national evaluation standard, it indicated soils were not contaminated;
(2) Single pollution index of Cadmium in shore side area of Shitouzhai River, branches of Shitouzhai River, Baima reservoir in Shitouzhai River, Baima bridge across Shitouzhai River, shore side area of Luositan River, Luositan bridge, downstream area of Longgong, Langgonghongyan power plant, 1<Pm≤2, it indicated soils were polluted in micro-degree; In shore sides area of Shitouzhai River and Langgonghongyan power station, 2<Pm≤3, it indicated soils were polluted in mild-degree; In the shore sides area of Luositan River, 3<Pm≤5, it indicated soils were polluted in moderate-degree.

4.2.2. Comprehensive Pollution Index Model (N.L.Nemerow)

N.L.Nemerow model is a quantity scale defined by National Soil Environmental Quality Standards and soil pollution monitoring results, and on the basis of evaluating the impact of in-situ soil environmental quality to social development. After the nondimensionalization of soil environmental quality index, the contribution of various environmental factors to the environmental pollution can be explained by numbers [6]. The formula is as follows:

\[
P_C = \sqrt{\frac{(AI P_m)(AI P_m) + (MaxI P_m)(MaxI P_m)}{2}}
\]

Note: Average Individual Pm (AI Pm) is the average value of soil pollution index.
Maximum Individual Pm (MaxI Pm) is the maximum number among all Pm. 
Pc is the comprehensive soil pollution index, the classification indices of soil comprehensive pollution index are showed in Table 6.

### Table 5. National Classification Standards of Soil Environmental Quality

| Class | Comprehensive Pollution Index | Pollution Degree | Pollution Level                          |
|-------|------------------------------|-----------------|-----------------------------------------|
| 1     | ≤0.7                         | Safe            | Clean                                   |
| 2     | 0.7<Pc≤1.0                   | Alert           | Relative Clean                          |
| 3     | 1.0<Pc≤2.0                   | Slight          | Might cause Crop Pollution              |
| 4     | 2.0<Pc≤3.0                   | Moderate        | Soil and Crop are moderately polluted  |
| 5     | Pc>3.0                       | Strong          | Soil and Crop are strongly polluted    |

Note: Pc means comprehensive pollution index of soils.

Calculation Method:
1. Based on each practical measured evaluation factors and soil classes’ scale from *National Soil Environmental Quality Standards (GB15618-1995)* in Huangguoshu Waterfalls scenic area, we can calculate the single pollution index of each factor (Table 5);
2. Compared measured contents of single heavy metal in soils and *National Soil Environmental Quality Standard Values*, we calculated the average value and maximum value of single heavy metal in soils.
3. According to the comprehensive soil pollution index model, comprehensive soil pollution indices were calculated (Table 7).

The following results can be obtained from Table 6 and Figure 1:
1. Pc of soil samples ranged from 0.7 and 3, number of samples whose security classification met national requirements and number of samples were heavily polluted was 0;
2. Pc of 31.8% of all collected samples ranged from 1 to 2, it indicated soils were slightly polluted by heavy metals;
3. Pc of 4.5% of all collected samples ranged from 2 to 3, it indicated soils were moderately polluted by heavy metals;
4. Pc of 63.7% of all collected samples ranged from 0.7 to 1, it indicated the pollution level of soils were above alert level.

![Figure 1. Comprehensive Pollution Index of Sampling Points](image-url)
Based on the spatial distribution, soil comprehensive pollution index in Shitouzhai area was 1.47, soil might cause crop contamination; soil comprehensive pollution index in Luositan area was 2.37, soil was moderately polluted by heavy metals; soil comprehensive pollution index in downstream area of Longgong was 0.88, soil pollution situation was above alert level; soil comprehensive pollution index in Langgonghongyan power plant was 1.48, soil was slightly polluted by heavy metals, soil might cause crop contamination (Table 7).

### Table 6. Monitoring Results of Pm and Pc in Huangguoshu Waterfalls Scenic Area

| Sampling Points                        | #  | Pb  | Cd  | Hg  | As  | Cr  | Pc  | Pollution Class | Pollution Level           |
|----------------------------------------|----|-----|-----|-----|-----|-----|-----|-----------------|---------------------------|
| Shore Side of Shitouzhai River          | 1  | 0.12| 2   | 0.26| 0.37| 0.4 | 1.48| Slight          | Might cause Crop Pollution|
|                                        | 2  | 0.15| 1.25| 0.86| 0.77| 0.4 | 1.01| Slight          | Might cause Crop Pollution|
|                                        | 3  | 0.12| 1.63| 0.41| 0.33| 0.46| 1.23| Slight          | Might cause Crop Pollution|
|                                        | 4  | 0.14| 1.65| 0.33| 1.01| 0.36| 1.21| Slight          | Might cause Crop Pollution|
|                                        | 5  | 0.11| 1.25| 0.3  | 0.5 | 0.33| 0.95| Alert           | Clean                     |
| Baima Reservoir in Shitouzhai River     | 6  | 0.08| 1.23| 0.26| 0.53| 0.27| 0.93| Alert           | Clean                     |
|                                        | 7  | 0.1 | 1.17| 0.24| 0.6 | 0.22| 0.89| Alert           | Clean                     |
|                                        | 8  | 0.14| 1.2 | 0.28| 0.45| 0.23| 0.91| Alert           | Clean                     |
|                                        | 9  | 0.09| 1.05| 0.29| 0.24| 0.21| 0.79| Alert           | Clean                     |
| Shoreside of Luositan River             | 10 | 0.12| 3.3 | 0.64| 0.22| 0.27| 2.42| Moderate        | Might cause Crop Pollution|
|                                        | 11 | 0.11| 1.25| 0.31| 0.34| 0.46| 0.95| Alert           | Clean                     |
|                                        | 12 | 0.1 | 1.28| 0.33| 0.34| 0.46| 0.88| Alert           | Clean                     |
|                                        | 13 | 0.11| 1.27| 0.37| 0.35| 0.5 | 0.97| Alert           | Clean                     |
|                                        | 14 | 0.1 | 1.25| 0.35| 0.5 | 0.53| 0.96| Alert           | Clean                     |
|                                        | 15 | 0.11| 1.2 | 0.38| 0.08| 0.51| 0.91| Alert           | Clean                     |
|                                        | 16 | 0.12| 2.63| 0.84| 0.2 | 0.55| 1.96| Slight          | Might cause Crop Pollution|
| Luositan Bridge                        | 17 | 0.1 | 1.23| 0.39| 0.17| 0.37| 0.93| Alert           | Clean                     |
|                                        | 18 | 0.1 | 1.28| 0.41| 0.13| 0.38| 0.96| Alert           | Clean                     |
| Downstream Area of Longgong            | 19 | 0.08| 1.16| 0.38| 0.19| 0.34| 0.88| Alert           | Clean                     |
| Langgonghongyan Power station          | 20 | 0.1 | 1.63| 0.37| 0.5 | 0.33| 1.23| Slight          | Might cause Crop Pollution|
|                                        | 21 | 0.12| 2.03| 0.33| 0.28| 0.25| 1.5 | Slight          | Might cause Crop Pollution|
|                                        | 22 | 0.08| 1.23| 0.36| 0.18| 0.26| 0.92| Alert           | Clean                     |
Table 7. Overall Pollution Situation of Sampling Points in Huangguoshu Waterfalls Scenic Spot

| Sampling Points                  | #Samples | Pb    | Cd    | Hg    | As    | Cr    | Pc   | Pollution Class                  | Pollution Level                        |
|---------------------------------|----------|-------|-------|-------|-------|-------|------|-----------------------------------|----------------------------------------|
| Shitouzhai                      | 1        | 0.12  | 2     | 0.26  | 0.37  | 0.4   |      | Slight Pollution                  | Might Cause Crop Contamination          |
|                                 | 2        | 0.15  | 1.25  | 0.86  | 0.77  | 0.4   | 1.47 |                                |                                         |
|                                 | 3        | 0.12  | 1.63  | 0.41  | 0.33  | 0.46  |      |                                |                                         |
|                                 | 4        | 0.14  | 1.65  | 0.33  | 1.01  | 0.36  |      |                                |                                         |
|                                 | 5        | 0.11  | 1.25  | 0.3   | 0.5   | 0.33  | 1.47 | Slight Pollution                  | Might Cause Crop Contamination          |
|                                 | 6        | 0.08  | 1.23  | 0.26  | 0.53  | 0.27  |      |                                |                                         |
|                                 | 7        | 0.1   | 1.17  | 0.24  | 0.6   | 0.22  |      |                                |                                         |
|                                 | 8        | 0.14  | 1.2   | 0.28  | 0.45  | 0.23  |      |                                |                                         |
|                                 | 9        | 0.09  | 1.05  | 0.29  | 0.24  | 0.21  |      |                                |                                         |
| Luositan                        | 10       | 0.12  | 3.3   | 0.64  | 0.22  | 0.27  | 2.37 | Moderate Pollution                | Moderate Pollution to Soils and Crops   |
|                                 | 11       | 0.11  | 1.25  | 0.31  | 0.34  | 0.46  |      |                                |                                         |
|                                 | 12       | 0.1   | 1.28  | 0.33  | 0.34  | 0.46  |      |                                |                                         |
|                                 | 13       | 0.11  | 1.27  | 0.37  | 0.35  | 0.5   |      |                                |                                         |
|                                 | 14       | 0.1   | 1.25  | 0.35  | 0.5   | 0.53  | 2.37 | Moderate Pollution                | Moderate Pollution to Soils and Crops   |
|                                 | 15       | 0.11  | 1.2   | 0.38  | 0.08  | 0.51  |      |                                |                                         |
|                                 | 16       | 0.12  | 2.63  | 0.84  | 0.2   | 0.55  |      |                                |                                         |
|                                 | 17       | 0.1   | 1.23  | 0.39  | 0.17  | 0.37  |      |                                |                                         |
|                                 | 18       | 0.1   | 1.28  | 0.41  | 0.13  | 0.38  |      |                                |                                         |
| Downstream Area of Longgong     | 19       | 0.08  | 1.16  | 0.38  | 0.19  | 0.34  | 0.88 | Alert                             | No Pollution                           |
| Langgong-ongy Power Station     | 20       | 0.1   | 1.63  | 0.37  | 0.5   | 0.33  | 1.48 | Slight Pollution                  | Might Cause Crop Contamination          |
|                                 | 21       | 0.12  | 2.03  | 0.33  | 0.28  | 0.25  |      |                                |                                         |
|                                 | 22       | 0.08  | 1.23  | 0.36  | 0.18  | 0.26  | 1.48 | Slight Pollution                  | Might Cause Crop Contamination          |
| Evaluation Area                 | 23       | 0.1   | 1.23  | 0.39  | 0.17  | 0.37  | 3.04 | Strong Pollution                  | Strong Pollution to Soils and Crops     |

5. Conclusion

5.1. Soils in evaluated area were alkaline.

From measured pH values of 22 soil samples, soil pH ranged from 7.18 to 8.28, most soils were slightly alkaline, it was determined by nature of soils.

5.2. The dominant soil pollution in the Huangguoshu Waterfalls scenic area was Cadmium contamination.

From the results of single factor pollution index, soil single factor pollution index was arranged as follows: Cadmium (Cd) > Arsenic(As) > Mercury (Hg) > Chromium (Cr) > Lead (Pb).

5.3. Based on the spatial distribution, the general soil comprehensive pollution index in the whole evaluation area had reached 3.04, it indicated soil was seriously polluted, and the growth of crops will be negatively affected.

In detail, soil comprehensive pollution index in Shitouzhai was 1.47, soil was seriously polluted by
heavy metals; soil comprehensive pollution index in Luositan area was 2.37, soil was moderately polluted by heavy metals; soil comprehensive pollution index in downstream area of Longgong was 0.88, soil pollution situation was alert-level; soil comprehensive pollution index in Langgonghongyan power station was 1.48, soil was slightly polluted by heavy metals.

6. Soil Remediation Measures in Huangguoshu Waterfalls scenic area

6.1. Chemical Remediation
It is found that the acidity and alkalinity of soils are significant factors that affect the migration rate of various heavy metals in soil. When pH is low, the adsorption capacity of heavy metals is weak; when pH ranges from 5 to 7, the adsorption capacity of heavy metals increases significantly; when pH is greater than 6, heavy metal cations in soil lead to hydroxides deposition by chemical reactions, on the contrary, heavy metal anions have stronger migration capacity.[7] Soil pH in Huangguoshu Waterfalls scenic area ranged from 7.18 to 8.28, heavy metal cations in soil were easier to produce precipitation and accumulate in soil, and cause heavy metal pollution. Therefore, for seriously polluted areas, we spread chemical drugs to reach acid-base neutralization, reduce soil alkalinity. For places where Cadmium pollution is more serious, we can spread Ethylenedinitrilo, then watering or water logging places where the chemicals were used, Cadmium in soil can be greatly degraded in this way.

6.2. Rehabilitation Project
The source of Cadmium pollution mainly came from two aspects: one is large amount of sewage discharged by local residents living along the river, the transportation of river currents accumulate Cadmium along both sides of river. The other one is irrational use of chemical fertilizer. As most of sample collection points are agricultural lands, local farmers use only one chemical fertilizer all year round, this monotonous method of fertilizer use resulted in cadmium accumulation and constituted great health risk. Therefore, on the one hand, we should improve propaganda and education of rational fertilizer use, encourage farmers to use organic fertilizer, and strengthen river related regulation. Forbid discharge untreated domestic sewage and industrial water into the river. On the other hand, in areas where Cadmium pollution is more serious, Ethylenedinitrilo can be used to degrade Cadmium in soil, and further processed by watering or water logging chemicals used spots.

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