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CHARACTERIZATION OF HEAVY METAL POLLUTION IN VEGETABLE FIELD SOILS AND HEALTH RISK ASSESSMENT IN DAYU COUNTY, CHINA
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中国大余县菜田土壤重金属污染特征及潜在生态风险评价

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ABSTRACT

The content of seven heavy metals (Cd, Pb, Cu, Cr, Zn, As, and Hg) in soil samples that collected from vegetable fields surrounding sewage irrigation district in Dayu County of China were detected and analyzed. The purpose of the analysis is to determine the harmful effects of heavy metal pollution to agricultural development through characterize the heavy metal pollution characteristics of soil. This study evaluated the heavy metal pollution index and the results show that, except for Pb, Cr, and Zn, the amount of majority heavy metals in most sites exceeded the Soil Environmental Quality Standard grade II level. In particular, the Cd pollution is the most serious with its contents exceed the standard level by 18.3 times. The nemerow comprehensive pollution index (NCPI) analysis shows that 90% of the sampling points are under moderate or severe pollution. In particular, NCPI is maximized to 13.22 in S-6. According to potential ecological risk (PER) assessment, the single-factor PER (Er) is Cd > Hg > As > Cu > Pb > Cr > Zn. The Er of Cd is maximized to 1,833.33 in S-6, indicating that Cd pollution in this site is extremely serious. Results of the comprehensive PER index (RI) indicats that all sites are under strong ecological risks. Therefore, soil pollution caused by heavy metals can severely harm the local agro-ecological environment.

摘要

通过对大余县污灌区周围菜田土壤样品中Cd、Pb、Cu、Cr、Zn和As、Hg等七种重金属含量的分析检测，目的在于通过分析土壤重金属的污染特征来表明当前重金属污染对农业发展带来的危害。结果表明，菜田土壤重金属除Pb、Cr、Zn外，其他重金属含量大部分超过《土壤环境质量标准》二级标准值，以Cd污染超标18.3倍最为严重。从内梅罗综合污染指数看，90%的采样点P综值达到中度或重度污染，以S-6的P综值达13.22最为严重。从潜在生态风险评价结果表明，单个元素潜在生态风险值Er按大小排序为：Cd> Hg> As> Cu> Pb> Cr> Zn，其中以S-6中Cd的Er值达到最大值为1833.33，说明该区域受Cd污染极为严重，其次RI值说明所有采样点都处于强生态风险程度以上。因此，由重金属引起的菜田土壤污染已严重危害当地农业生态环境。

INTRODUCTION

The rapid economic development has currently triggered a series of pollution problems, particularly the heavy metal pollution (*Zhang Wei, et al., 2015*). The content of several heavy metals in soils have exceeded allowable levels or even the background levels because of human production and living activities. These heavy metals cannot be decomposed or utilized by microorganisms *(Dou Zhiyong, et al., 2015*), but will be enriched by organisms. These heavy metals in soils have a long retention time and poor mobility *(Ma Jianhua et al., 2014; Zheng Hongyan et al., 2015)*. In recent years, many reports on soil heavy metal pollution have been published *(Olawoyin R., et al., 2012)*. Soil heavy metal pollution mainly originates from farmland sewage irrigation and pesticide application. In April 2015, the Ministry of Agriculture stated that wastes from mines and industrial plants are discharged into agriculture lands, which leads to the decrease in agricultural production and environmental quality. Long-term and excessive use of fertilizers and pesticides and improper waste disposal caused serious agricultural non-point source pollution.(*An Jing, et al., 2016*) The primary source of heavy metals, according to the Department of Environmental Protection, was irrational exploitation mining (*Liu Shuo et al., 2016*), which is also one of the main causes of serious pollution in agricultural lands.

Dayu County in Jiangxi Province, China has many large-scale tungsten mines and is called the “world capital of tungsten”. Accompanied by the rapid economic development, tungsten mining also causes severe pollution, as the disorder mining produces large amounts of waste water that containing heavy metals. It has jeopardized the farmland soil, water and other agricultural resources. China is a large agricultural country, which primarily relies on irrigation and agricultural development; therefore, agricultural pollution affects not only the GDP of the country but also the life and health of people. However, only a few studies on heavy metal pollution in the farmland fields surrounding sewage irrigation district in Dayu County have been conducted. Thus, in this study, we selected the vegetable soil heavy metal pollution as one of the representatives in farmland pollution and characterized the heavy metal contents in vegetable soils surrounding sewage irrigation district in Dayu county. On this basis, we assessed the potential ecological risks (PERs) in the area which will provide a good reference and theoretical basis for better management of the agricultural environment in Dayu.

MATERIAL AND METHOD

Study area

Dayu County (E 114°–114°44′, N 25°15′–25°37′) is located in the southwest of Jiangxi Province and the upstream of Zhangjiang River, which passes through Dayu from west to east. The northern part of Dayu is adjacent to Luoxiao Mountains and Chongyi County, the eastern part is adjacent to Nankang County, the southern part is adjacent to Nanxiong City of Guangdong Province, and the western part is adjacent to Renhua County of Guangdong. Xihuashan Tungsten Mine (6.48 km^2), which is located in the north-western part of Dayu. Samples of vegetable field soils and vegetables were collected from the tailing southward along riverbanks surrounding sewage irrigation district.

Sample collection and analysis

Samples of vegetable field soils were collected in June 2015. In particular, samples were collected in a quincunx manner, according to the Technical Specification for Soil Environmental Monitoring (HJ/T166-2004) and terrain characteristics of the area. The point positions were recorded by a Global Positioning System (GPS). Surface soils (0–20 cm) in good condition were selected. In total, 10 soil samples were collected. The soil samples were packed into clean and marked sampling bags and transported to our laboratory for analyses and tests. The sampling sites were shown in Fig.1

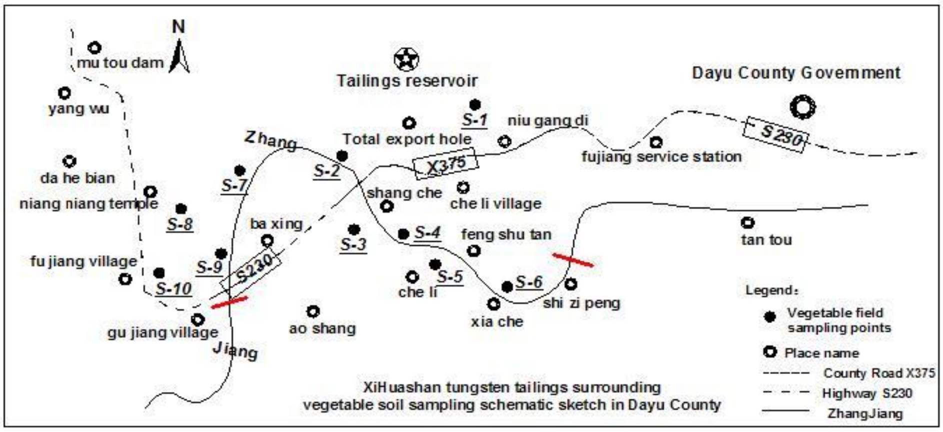

Fig.1 - Vegetable field soil sampling sites

After natural drying, impurities, including small stones and plant residues, were removed from the soil samples. Approximately 1kg of soil was collected from each sample by using the quartation method. Then, the samples were ground and screened by using a 100 mesh nylon screen. Table 1 showed the soil sample pretreatment methods.

Table 1

Soil sample pretreatment methods

Item	Soil sample				
	pH	SOM	CEC	Cu, Pb, Zn, Cr, Cd	As, Hg
Method	Water–soil ratio 2.5:1	Potassium dichromate–volumetric method	$BaCl_2$–H_2SO_4 method	HNO_3–HF–$HClO_4$ digestion[1]	Aqua regia digestion[2]
Equipment	PHS-3C mine magnetic pH meter	Acid titration	Acid titration	AAS	AFS-8220 meter

Note: AAS: atomic absorption spectrophotometer; AFS: atomic fluorescence spectrophotometer; SOM: soil organic matter; CEC: cation exchange capacity

[1]:Liu Yan, et al., 2013; [2]:Zhao Ximei, et al., 2014

All samples were tested by using the Chinese National Standard Soil References (GBW07405). The reliability of data was analyzed through spiked recovery control (80%–120%) and parallel control (relative standard deviation <10%) *(He Yusheng et al., 2015)*; therefore, the measured data were controlled within permissible error ranges.

Data processing

Statistical processing and plotting were conducted on Origin 7.5 and Excel 2013. Statistical analysis was conducted on SPSS 20.0. Correlations between heavy metals and soil physicochemical properties were analyzed by using Pearson's method.

Evaluation methods

Pollution indices are used to characterize heavy metal pollution in vegetable field soil in agriculture. The single-factor pollution index (SFPI) *(Wang Youqi et al., 2014; Liu Yan et al., 2013)* reflects the pollution degree of a single pollutant. For a more comprehensive and integrated evaluation of soil pollution, the Nemerow comprehensive pollution index (NCPI) *(Wang Lixia et al., 2005)*. PERs in this region were also assessed.

(1) The SFPI is used to evaluate the pollution degrees of single pollutants. The SFPI is computed as follows:

$$Pi = \frac{Ci}{Si} \tag{1}$$

where P_i is the SFPI of pollutant *i* in soil, C_i is the measured content of pollutant *i* (mg·kg^{-1}),S_i is the evaluation standard of pollutant *i* (mg·kg^{-1}) from the Soil Environmental Quality Standard grade II level (GB 15618-1995).

(2) The NCPI can comprehensively reflect the soil pollution degree of all pollutants. The NCPI is computed as follows:

$$P_{com} = \sqrt{\frac{\left(Ci/Si\right)^2_{\max} + \left(Ci/Si\right)^2_{ave}}{2}} \tag{2}$$

where P_{com} is the NCPI of pollutants in a soil sample, $(C_i / S_i)_{max}$ is the maximum value of NCPI in this region (mg·kg^{-1}),$(C_i/S_i)_{ave}$ is the average NCPI of pollutants in this region (mg·kg^{-1}). The evaluation criteria are listed in Table 2.

Table 2

Grading criterion of soil heavy metal pollutions

Grade	**SFPI grading criterion**			**NCPI grading criterion**		
	Pollution index	**Pollution grade**		**Pollution index**	**Pollution grade**	
1	$P_i < 1$	Clean	I	$P \leq 0.7$	Safe	I
2	$1 \leq P_i < 2$	Slight	ii	$0.7 < P \leq 1$	Warn	II
3	$2 \leq P_i < 3$	Medium	iii	$1 < P \leq 2$	Slight	III
4	$P_i \geq 3$	Heavy	iv	$2 < P \leq 3$	Medium	IV
5				$P > 3$	Heavy	V

Assessment of soil potential ecological risk (PER), The PER index *(Gao Peng, et al., 2015; Xu Zhongyi et al., 2014)* is used to evaluate the potential risk of a single heavy metal or the comprehensive risk of several heavy metals in a region. The PER index is computed as follows:

$$E^i_r = T^i_r \times \frac{Ci}{Si} \tag{3}$$

$$RI = \sum E^i_r \tag{4}$$

where C_i is the measured content of heavy metal *i* (mg·kg^{-1}), S_i is the background level of heavy metal *i* (mg·kg^{-1}), E^i_r is the single PER index of heavy metal *i*, *RI* is the comprehensive PER index of heavy metals in a region. The toxicity response coefficients of heavy metals used in this research are (T^i_r) *(Lars H., 1980)*: Cd = 30; Pb = Cu = 5; Cr = 2; Zn = 1; As = 10; Hg = 40. The relevant PER assessment grades are listed in Table 3.

Table 3

Potential ecological risk division level

E^i_r	*RI*	**Pollution degree**	**Grade**
$E^i_r < 40$	$RI < 150$	Slight PER	I
$40 \leq E^i_r < 80$	$150 \leq RI < 300$	Medium PER	II
$80 \leq E^i_r < 160$	$300 \leq RI < 600$	Severe PER	III
$160 \leq E^i_r < 320$	$RI \geq 600$	Very severe PER	IV
$E^I_r \geq 320$		Extremely severe PER	V

RESULTS

Distribution of heavy metal contents in vegetable field soils

As shown in Table 4, soil samples S-1, S-2, S-3, S-7, S-9, and S-10 are below pH 6.5, and other samples are within pH 6.5–7.5, which are consistent with the characteristic of partial acid vegetable field soil in south Jiangxi and corresponding to grade II of the national standards. Except for S-4, the Cd contents in other sample sites are within 0.5–5.5, which all exceed the grade II level, particularly in S-6, which is 18.3-fold higher. No sample exceeds the grade II levels of Zn, Cr, or Pb. As for Cu, except for S-5, other samples exceed the grade II level, particularly in S-9, which is 3.32-fold higher. As for As, 80% samples exceed the grade II level, particularly in S-2, S-6, and S-8. As for Hg, except for S-5, S-6, S-9, and S-10, other sites exceed the grade II level of Hg, particularly in S-1 and S-3, which exceed the level by more than 3-fold.

Table 4

Statistical description of soil heavy metal contents

Site	**pH**	**SOM ($g \cdot kg^{-1}$)**	**CEC ($cmol \cdot kg^{-1}$)**	**Heavy metal ($mg \cdot kg^{-1}$)**						
				Cd	**Pb**	**Cu**	**Cr**	**Zn**	**As**	**Hg**
S-1	6.45	31.8	14.5	1.2	59.8	116.9	76.4	75.9	79	1.2
S-2	6.3	45.79	17.6	2.8	92.9	100.5	67.7	88.3	103.5	0.49
S-3	4.8	31.28	13.5	1.2	88.8	82.1	63.3	65.3	23	0.97
S-4	7.21	22.61	10.5	0.2	80.5	122.7	45.9	98.5	35.6	0.71
S-5	6.5	22.54	11.8	1.2	88.8	92.8	50.2	82.6	8.8	0.12
S-6	6.68	21.53	9.6	5.5	84.6	179.7	37.1	139	92.4	0.2
S-7	5.99	21.89	10.2	1.9	84.6	112.1	59	81.9	50.9	0.65
S-8	6.65	34.56	16.5	3.5	142.7	192.3	72.1	122.2	112.2	0.8
S-9	5.38	22.36	11.2	0.5	126.1	166.2	72.1	98.5	55.6	0.1
S-10	4.91	27.11	12.8	1.9	167.6	83.1	102.6	70.6	49	0.24
Mean	–	–	–	2	101.64	124.84	64.64	92.28	61	0.55
SD	–	–	–	1.58	33.03	40.4	18.41	23.19	34.68	0.38
CV/100%		–	–	79	32	32	28	25	57	69
Chinese grade II		pH	<6.5	0.3	250	50	150	200	40	0.3
			6.5–7.5	0.3	300	100	200	250	30	0.5
			>7.5	0.6	350	100	250	300	25	1
Background in Jiangxi			–	0.1	32.1	20.8	75	69	10.4	0.08
Background in Ganzhou			–	0.09	34.19	15.17	34.56	58.05	8.85	0.06

Note: CV: variation coefficient; SD: standard deviation

The majority of tested heavy metals significantly exceed the soil background levels in Jiangxi or Ganzhou. The contents of Cd, Pb, Cu, Cr, Zn, As, and Hg exceed the background levels in Ganzhou by 2.22–61.11, 1.75–4.90, 5.41–12.68, 1.07–2.97, 1.12–2.39, 0.99–12.68, and 1.67–20 times, respectively. In particular, the Cd content in site S-6 exceeds by 61.11-fold. S-6 is located downstream of Zhangjiang River and is affected by rainwater erosion because of the low terrain, which probably brought heavy metals from the tailing. The variation coefficient reflects the discrete degree of samples, with a large value indicating a more severe artificial disturbance or more serious pollution. The distribution of Cd content shows significant geographical difference or significant external interference (mainly intense human activities). The variation coefficients of Zn, Cr, Pb, and Cu are similar at 25%, 28%, 32%, and 32%, respectively, indicating that none of the four heavy metals show significant geographical difference and have uniform external influence. The distributions of these heavy metals might be homologous in this region, according to the variation coefficients of vegetable field soil heavy metals in Taicang City *(Zhang Xiaolan, et al., 2007)*. As shown in Fig. 1, S-3 and S-5 are located in the other bank opposite to the ailing and are less affected by the tailing, which probably led to the large differences in As contents. Therefore, in terms of heavy metal content in soil, long-term exploration activity have resulted in extremely serious pollution of agricultural land, which is one of the factors that restrict agricultural production activities.

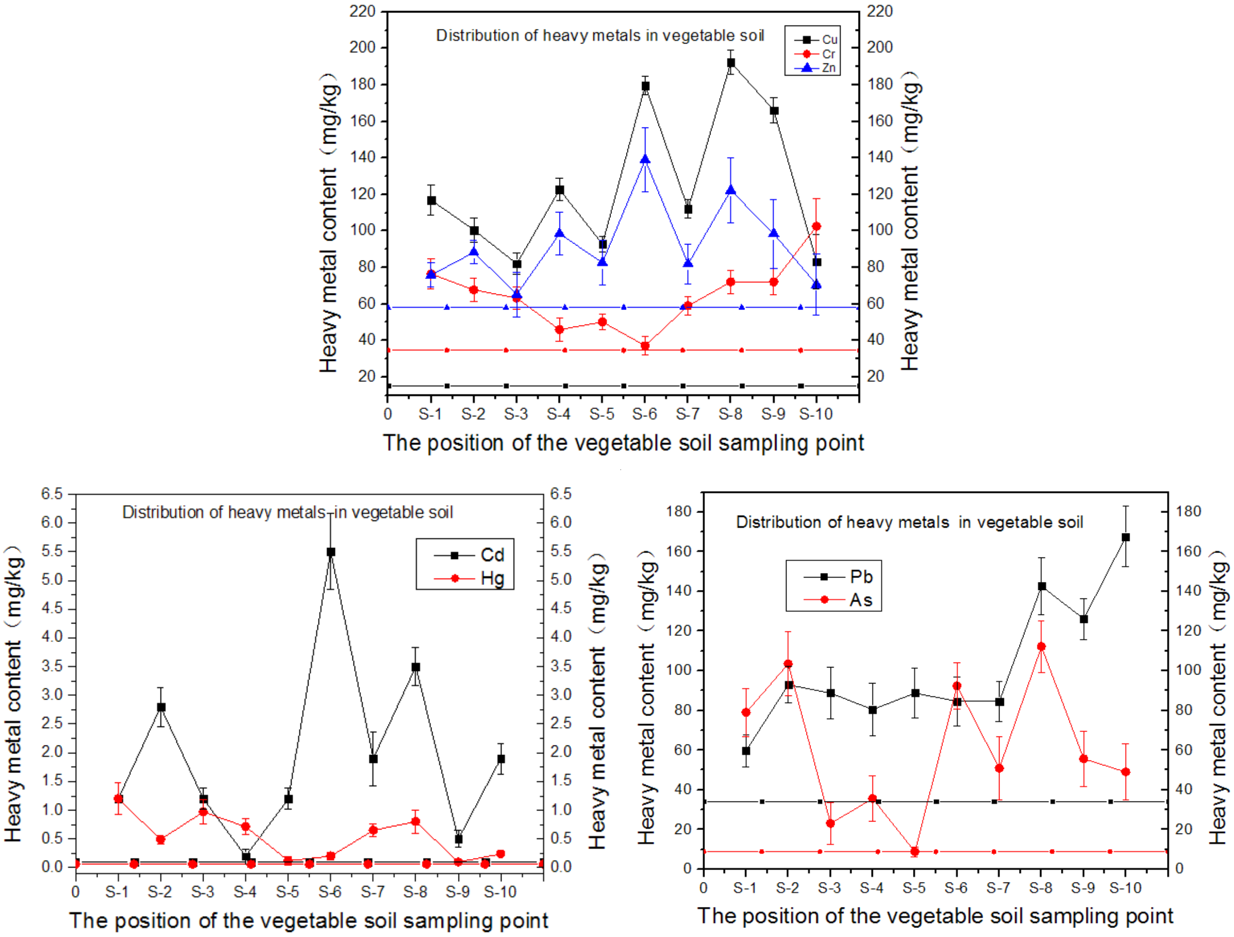

Fig.2 - Distribution of heavy metal contents in vegetable field soils

Note: Dash indicates Ganzhou soil background value

Fig.2 shows the histograms of heavy metal content distribution at all sampling sites. As shown in the figure, the soil heavy metal contents in S-2, S-6, and S-8 are generally higher than that in other sites. In particular, soil heavy metal pollution is extremely severe in S-2 probably because of the influence of the nearby tailing and its location in the sewage irrigation area. Soil heavy metal pollution is very severe in S-6 because S-6 is located downstream of Zhangjiang River and is affected by rainwater erosion, which probably brought heavy metals from the tailing because of its low terrain. Soil heavy metal pollution is extremely severe in S-8, because insecticide use and geological conditions, including its location in upper river, original state without mining, high background value of heavy metal content within the geological strata structure.

Correlation analysis in vegetable field soils

The correlations between heavy metals and soil physicochemical properties in vegetable fields by using Pearson’s correlation method. Thereby, we preliminarily determined the correlations between heavy metals and physicochemical properties and whether the sources were similar among different heavy metals. This analysis of agricultural production activities as source pollution had a certain reference value. The results are listed in Table 5.

Table 5

Correlation analysis (Pearson) between heavy metals and soil physiochemical properties

	Cd	Pb	Cu	Cr	Zn	As	Hg	pH	SOM	CEC
Cd	1									
Pb	0.097	1								
Cu	0.499	0.155	1							
Cr	−0.229	0.665*	−0.272	1						
Zn	0.697*	0.057	0.896**	−0.501	1					
As	0.677*	0.134	0.615	0.122	0.586	1				

	Cd	Pb	Cu	Cr	Zn	As	Hg	pH	SOM	CEC
Hg	−0.185	−0.414	−0.126	0.094	−0.284	0.156	1			
pH	0.23	−0.459	0.42	−0.614	0.581	0.322	0.106	1		
SOM	-0.152	-0.172	-0.199	0.207	−0.269	0.282	0.117	−0.204	1	
CEC	0.1	0.188	0.084	0.468	−0.163	0.524	0.396	−0.035	0.691*	1

Note: *$p < 0.05$; **$p < 0.01$ (two-sided).

As shown in Table 5, significant positive correlations are observed among Cd, Zn, As, and Cu, together with the characteristics of regional heavy metal pollution. The contaminants from the sewage irrigation district are dominated by Cd, accompanied by As, Cu, and Zn. Pb and Cr contents are also significantly and negatively correlated with pH In particular, a higher pH lead to lower Pb or Cr content, and vice versa. However, the changes are different from Cu and Zn. Hg is not significantly correlated with other heavy metals~~,~~ whether Hg originated from atmospheric precipitation should be further investigated. As and Cr contents are significantly and positively correlated with CEC, indicating that CEC promoted the absorption of As and Cr. Thus, long-term mining or heavy metal accumulation in soil from chemical fertilizers, pesticides, and other changes in soil physical and chemical properties can be inferred as the sources of heavy metal contaminants in agricultural soil.

Assessment of soil heavy metal pollution

- *Pollution indices*

SFPI and NCPI, with grade II of the national standards as reference, were used to evaluate the vegetable field soils surrounding the sewage irrigation district (Table 6).

Table 6

Assessment of soil heavy metal pollutions

Metal	**Site**																			
	S-1		**S-2**		**S-3**		**S-4**		**S-5**		**S-6**		**S-7**		**S-8**		**S-9**		**S-10**	
	P	**GRD**	**P**	**GRD**	**P**	**GRD**	**P**	**GRD**	**P**	**GRD**	**P**	**GRD**	**P**	**GRD**	**P**	**GRD**	**P**	**GRD**	**P**	**GRD**
Cd	4	iv	9.3	iv	4	iv	0.67	i	4	iv	18.3	iv	6.33	iv	11.67	iv	1.67	ii	6.33	iv
Pb	0.2	i	0.4	i	0.36	i	0.27	i	0.36	i	0.34	i	0.34	i	0.57	i	0.5	i	0.67	i
Cu	2.3	iii	2	iii	1.64	ii	1.23	ii	1.86	ii	3.59	iv	2.24	iii	3.85	iv	3.32	iv	1.66	ii
Cr	0.5	i	0.5	i	0.42	i	0.23	i	0.33	i	0.25	i	0.39	i	0.48	i	0.48	i	0.68	i
Zn	0.4	i	0.4	i	0.33	i	0.39	i	0.41	i	0.7	i	0.41	i	0.61	i	0.49	i	0.35	i
As	2	ii	2.6	iii	0.58	i	1.19	ii	0.22	i	2.31	iii	1.27	ii	2.81	iii	1.39	ii	1.23	ii
Hg	4	iv	1.6	ii	3.23	iv	1.42	ii	0.4	i	0.67	i	2.17	iii	2.67	iii	0.33	i	0.8	i
NCPI	3.1	V	6.8	V	2.52	IV	1.14	III	2.93	IV	13.2	V	4.67	V	8.56	V	2.49	IV	4.63	V

Table 6 shows that the SFPIs of Pb, Cr, and Zn in all samples, SFPIs of a part of Hg and As, and SFPI of Cd in S-4 are marked “clean,” whereas the SFPIs in other cases are marked “slight,” “medium,” or even “severe” pollution. The most aggressive pollutant is Cd. 80% of the sites are severely polluted largely, because these areas are located near the tailing and significantly affected by the tailing. Cu pollution in S-6, S-8, and S-9 and Hg pollution in S-1 and S-3 are severe. Results of the NCPI indicate that all sites are polluted. In particular, S-4 has the smallest NCPI and is slightly polluted mainly because Cd pollution at S-4 is at the “clean state.” The NCPIs of approximately 60% of the sampling sites are severely polluted, which are ranked as S-6 > S-8 > S-2 > S-7 > S-10 > S-1. The highest NCPI in S-6 ($P = 13.22$) is attributed to the largest contribution of Cd pollutant and severe pollutions of Cu and Hg.

- *Assessment of potential ecological risk*

With the background levels in Ganzhou as references, the *Er* of seven heavy metals and the RI in each sampling site in this sewage irrigation district were computed. Based on relevant PER assessment grades listed in Table 3, the PERs in the study area were estimated. The results are listed in Table 7.

Table 7

Potential ecological risk of heavy metals in vegetable soils in the study area

Site	**E^i_r**							***RI***	**Risk grade**
	Cd	**Pb**	**Cu**	**Cr**	**Zn**	**As**	**Hg**		
S-1	400	8.75	38.53	4.42	1.31	89.27	800	1,342.27	IV
S-2	933.33	13.59	33.13	3.92	1.52	116.95	326.67	1,429.09	IV
S-3	400	12.99	27.06	3.66	1.13	25.99	646.67	1,117.09	IV

S-4	66.67	11.77	40.44	2.66	1.7	40.23	473.33	1,117.49	IV
S-5	400	12.99	30.59	2.91	1.42	9.94	80	537.84	III
S-6	1,833.33	12.37	59.23	2.15	2.39	104.41	133.33	2,147.22	IV
S-7	633.33	12.37	36.95	3.41	1.41	57.51	433.33	1,178.33	IV
S-8	1,166.67	20.87	63.38	4.17	2.11	126.78	533.33	1,917.31	IV
S-9	166.67	18.44	54.78	4.17	1.7	62.83	66.67	375.25	III
S-10	633.33	24.51	27.39	5.94	1.22	55.37	160	907.75	IV

As shown in Table 7, the PERs of Pb, Cr, and Zn in vegetable soils are at a “slightly polluted” level, indicating that this area is not significantly harmed by these three heavy metals. Cu contents in 60% of the sites and As contents in 20% of the sites show slight PER; As contents in 40% of the sites show medium PER, but the remaining 40% of the sites show heavy PER (Fig. 1), indicating that As pollution in these areas are significantly affected by human disturbance and geological structure disturbance. As for Cd, S-4 and S-9 is not higher than high PER, and the remaining sites are at very high PER, with up to 1,833.33 as the highest *Er*. As for Hg, S-9, S-6 and S-5 are not higher than high PER, S-10 is at high PER, and the remaining sites are at very high PER, with up to 800 as the highest *Er*. Hg pollution might originate from the dusts due to mining, which then precipitate through air ash onto vegetable soils. Then, according to the RIs, 80% of the sites are at very high PER, indicating that these areas are at a bad eco-environment state largely. because of the eco-environmental risk causes. Therefore, based on the evaluation of heavy metal pollution in vegetable soil, local agricultural production activities are inhibited by heavy metal pollution and long-term mining significantly affects the sustainable development of agriculture.

CONCLUSIONS

Use of the heavy metal pollution index to characterize the soil contaminated by heavy metals to determine the harmful effects of heavy metal pollution to agricultural development. shows the following:

- Except for Pb, Cr, and Zn, the contents of the rest of the heavy metals exceed the Soil Environmental Quality Standard grade II level. Cd pollution is the most severe. The seven heavy metals all cause serious pollution according to the Ganzhou soil background levels, which indicate a significant accumulation of heavy metals in the field of ecological agriculture.
- .Cd, Zn, As, and Cu are significantly and positively correlated, but other heavy metals are not significantly correlated. Pb and Cr contents are significantly and negatively correlated with pH, or the acid conditions improve the activities of Pb and Cr. The amounts of As and Cr in soil are significantly and positively correlated with CEC, indicating that CEC promotes the absorption of As and Cr.
- The SFPI analysis shows that heavy metal pollution in vegetable soil is similar to (1), because Cd pollution is the most severe and approximately 80% of the sampled points .The NCPI analysis shows that S-4 was slightly polluted, whereas the other sites are moderately or severely polluted. The NCPI of S-6 is the largest (13.22). The *Er* of the single-element PER ranking is Cd > Hg > As > Cu > Pb > Cr > Zn, As for Cd, 80% sites are at very high PER, with up to 1,833.33 as the highest *Er*. All RIs show strong ecological risk, or it has already a serious harm to the ecological agriculture.

In a word, Cd pollution is the serious pollution in the sampling areas, and it has strong potential ecological risk, causing a bad influence upon the development of agriculture. Or this study shows that long-term mining exploration activities caused serious heavy metal pollution to surrounding agricultural areas .Heavy metal pollution in agricultural soil is one of the factors that significantly restrict agricultural development, which affects the economic development and GDP growth of the area. Meanwhile, the potential risks of heavy metal soil contaminants on human health should be further investigated.

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