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Original Research

Ecological and Health Risk Assessment of Heavy Metals in Soils of Vegetable Base in North of Suzhou, Anhui Province, China

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Abstract

In order to investigate the pollution characteristics, potential ecological risks and health risks of heavy metals in the soil of the north vegetable base in Suzhou, Anhui, surface soil samples were collected from three vegetable growing areas in the urban (Northern) area, the contents of seven heavy metal elements (Cu, Zn, Co, Ni, Cr, Mn and Pb) in the samples were analyzed, the accumulation and potential risk of heavy metals in soil were evaluated by using soil heavy metal pollution index, potential ecological risk assessment and health risk assessment. The results show that there are middle and light Zn enrichment and heavy Pb enrichment in this area according to the evaluation method of Pollution Index. According to the result of potential ecological risk assessment, the light ecological risk is the main risk in the study area. According to the health risk assessment, there is a non-carcinogenic risk from skin inhalation and a carcinogenic risk from hand, mouth and skin contact in adults and children, areas A and C of the site are major areas for reducing pollution and protecting human health risks.

Keywords: vegetable base, heavy metals, health risk assessment, Suzhou area

Introduction

Soil is one of the important factors affecting the ecological environment, is the direct source of nutrition for crops, and is also an inseparable environmental medium for human survival and production [1-3]. In recent years, soil heavy metal pollution has become increasingly serious, which not only affects the yield and quality of agricultural products, but also leads to human health and environmental safety problems [4-6]. Heavy metal pollution in soil is easy to accumulate, difficult to migrate, long-term and latent, which leads to irreversible heavy metal damage in several years or even decades [7-9]. As the soil is affected by mining, sewage discharge and the use of heavy metal products that exceed the standard, the agricultural and sideline products planted are also polluted by heavy metals to varying degrees, which can eventually be transmitted through the food chain and endanger human health

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[10-12]. Therefore, the study on the geochemistry characteristics and pollution of heavy metals in soil has received extensive attention. Vegetables, as the main source of vitamin C and fiber intake, are essential for human survival, so heavy metal pollution in vegetable bases has always been a hot topic.

In recent years, many scholars at home and abroad have used the single factor index method, the Nemero comprehensive pollution index method, the land accumulation index method, the potential ecological hazard index method and other methods to study the content of heavy metals in cultivated soil in many aspects, including the concentration of heavy metals, the form of heavy metals, the spatial distribution characteristics, source analysis and pollution evaluation [13-15]. For example, the pollution characteristics and sources of Cd, Pb, etc. in paddy soil of a county in Hunan Province by Muli et al. [16]. Zhang Xuhui studied the level and distribution of Pb, Cd, Cr in farmland soil in Yunnan [17].Ren Qiong and others conducted spatial distribution characteristics and analysis and evaluation of mercury, arsenic and lead in the soil of Poyang Lake wetland [18]. Zhang Chengli and others used the MMSOILS risk assessment model to evaluate the health risks of heavy metals to adults and children caused by eating cereal crops around the coal mines in Yuzhou City, Henan Province [19]. Liu Tong evaluated the ecological health risk of heavy metals in the soil of eastern Yinan County, Shandong province, and found that Hg and Cd were the main ecological risk elements [20]. A health risk assessment of heavy metals in soils around the Chengchao mining area by Yang Yanhu found that both the non-carcinogenic and carcinogenic risks of As and Cr were prominent in the area [21] Suzhou is a typical agricultural city and an important production base of agricultural products in China. It is mainly planted with cash crops, covering an area of 10.1234 million mu. Previous researchers have done little research in this area, and lack of deeper research on local ecological risks and health risks of local residents.

In this paper, the surface soil of Suzhou North Vegetable Base was selected as the research object. Through the systematic collection of heavy metals (Cu, Zn, Co, Ni, Cr, Mn and Pb) in the soil of the vegetable park, the content of the samples was determined by X-ray fluorescence spectrometer, and the pollution characteristics of heavy metals in the soil of the vegetable base were mastered by the evaluation method of soil heavy metal pollution index; The potential ecological risk and the health risk assessment model of the United States Environmental Protection Agency (USEPA) are used to systematically evaluate the ecological and health risks of the vegetable base, aiming at providing scientific basis for the protection of the health of the surrounding residents and the sustainable use of the cultivated land environment.

Materials and Methods

Study Area

Suzhou is a prefecture-level city under the jurisdiction of Anhui Province. It is built into an emerging central city in the intersection of Anhui, Jiangsu, Shandong and Henan provinces. The geographical location is located in the north of Anhui Province, in the northeast of Huaibei Plain, most of which are plain depressions. It is between 115°09'-117°10'E and 33°18'-34°38'N. The local climate belongs to the north temperate semi-humid monsoon climate, with long summer and winter, and short spring and autumn. It is hot in summer and cold in winter. The soil types in the city are mostly tidal soil and sandy ginger black soil, which are deep and suitable for the growth of various crops and animal husbandry. The main crops are wheat, cotton, soybean, corn, yam, peanut, sesame, etc. The research area is planted with wheat, pepper, watermelon, grapes, etc., all of which are fertile black land, close to Avenue. The sampling location is determined to be divided into three locations in the vegetable park around Suzhou, as shown in Fig. 1.

Sample Collection and Processing

The sampling work will be completed in June 2021, and four sampling areas will be set in the vegetable greenhouse bases on both sides of the road. According to the site conditions, every sampling area shall be three units per 100 meters layout, each cell represents a sampling point.

When taking soil on site, use a sampler to collect 3-10 cm of soil in the farmland, remove impurities such as tree roots, and retain about 1kg of soil sample as the analysis sample of the sampling point, bag it, affix a label and take it back to the laboratory. Put the collected soil sample in a cool and ventilated place to dry naturally to remove the sundries in the sample, grind it to 0.074 mm mesh screen in turn, and then put it in a sealed bag for storage for testing. Finally, take about 5g of powder samples from each sampling point and put them into a manual tabletop tablet press to press them into about 0.5mm thin slices, and seal them with sealed bags for further determination.

The content of heavy metals Cu, Zn, Co, Ni, Cr, Mn and Pb in the sample slice was determined by X-ray fluorescence spectrometer. This method has the characteristics of wide detection of elements and fast detection speed.

Assessment Method for Heavy Metal Pollution Index of Soil (EF and MPI)

The modified pollution index was used to evaluate the pollution of heavy metals in the surface soil of coal mining areas. The modified pollution index (MPI) is a comprehensive pollution index evaluation method

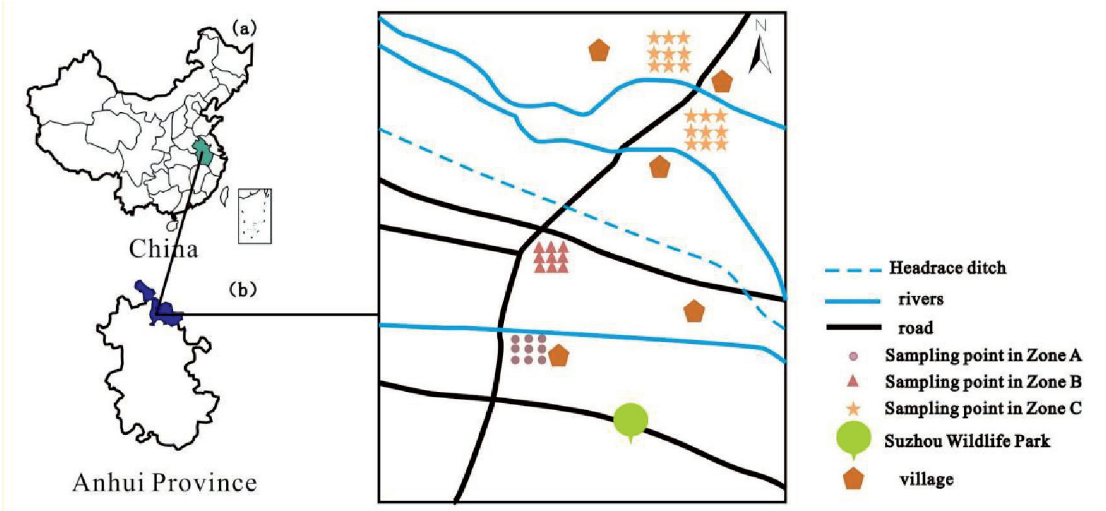

Fig. 1. Regional geographical location and distribution of sampling points. a) China; b) Structural map of northern Suzhou; c) Location of sampling points.

proposed by Brady in 2015 [22]. It is superior to other pollution indexes in evaluating heavy metal pollution in soil and sediment due to its high threshold of pollution index and avoiding the use of pollution factors. The calculation formula is described as (1) and (2).

$$\mathrm{EF} = \frac{\left(\frac{\mathrm{Ci}}{\mathrm{Fe}}\right)_{\mathrm{Sample}}}{\left(\frac{\mathrm{Cn}}{\mathrm{Fe}}\right)_{\mathrm{Background}}} \quad (1)$$

$$\mathrm{MPI} = \sqrt{(\mathrm{EF_{ave}})^2 + (\mathrm{EF_{max}})^2} \quad (2)$$

In formula (1): n represents any element, C_i is the actual measured value of element i ($mg.kg^{-1}$), C_n is the background value of n element. This paper takes the background value of soil in Anhui Province as the evaluation standard, in which the content of Fe is 3400 $mg.kg^{-1}$.In formula (2), EF_{ave} is the average enrichment factor of each heavy metal. EFmax is the maximum value of each heavy metal enrichment factor. See Supplementary Table 1 for pollution assessment level.

Single Factor Pollution Index (P_i)

The single-factor pollution index P_i is an important method to evaluate the pollution degree of a heavy metal in soil [23]. The Nemerow comprehensive pollution index P is a weighted multi-factor environmental quality index that takes into account the average value of the single factor pollution index and highlights the maximum value. Because it comprehensively considers the impact of various metals in soil on environmental quality, it is widely used at present. The calculation formula is (3) and (4). Table 1 shows the evaluation criteria of pollution degree.

$$P_i = C_i \div S_i \quad (3)$$

$$P = \left\{\left[\left(P_{i,max}\right)^2 + \left(P_{i,ave}\right)^2\right] \div 2\right\}^{1/2} \quad (4)$$

In formula (3): P_i is the single factor pollution index, P is the Nemerow comprehensive pollution index, C_i is the measured content of element i, S_i is the reference standard content of i element, $P_{i,ave}$ is the average value of environmental quality index of elements at sampling point i, $P_{i,max}$ is the maximum value of the environmental

Table 1. Grading standard for Enrichment Factor and Modified Pollution Index.

Rank	EF value	MPI value	Enrichment level	Pollution level
1	≤1	<1	No enrichment	Unpolluted
2	1-2	1-2	Light enrichment	Slightly polluted
3	2-5	2-3	Moderate enrichment	Moderately polluted
4	5-20	3-5	Significant enrichment	Moderately to heavily polluted
5	20-40	5-10	Strong enrichment	Heavily polluted
6	>40	>10	Extreme enrichment	Severely polluted

Table 2. Classification standard of soil heavy metal pollution.

Nemero comprehensive pollution index			
Pi	Class of pollution	Pn	Class of pollution
≤1	Clean	≤0.7	Clean
1~2	Mild pollution	0.7~1	Cordon
2~3	Moderate pollution	1~2	Mild pollution
>3	Severe pollution	2~3	Moderate pollution
		>3	Severe pollution

quality index of the elements at the sampling point i. Table 2 complements the levels of pollution index.

Potential Ecological Risk Index (E_r^i)

The potential ecological risk index is based on the physical and chemical properties of heavy metals and the interaction of the environment, which is proposed by the Swedish scholar Hakanson, and is evaluated by the comparable equivalent attribute index grading method [24]. The calculation formula is (5).

$$E_r^i = T_r^i \times P_i \tag{5}$$

In the formula, E_r^i is the single factor potential ecological risk index of heavy metal element i, <40 is the slight potential ecological risk, 40<=>80 is the medium potential ecological risk, 80<=<160 is the strong potential ecological risk. P_i is the environmental quality index of heavy metal element i in soil. T_r^i is the toxicity response coefficient of heavy metal i. At present, scholars generally directly use the toxicity coefficient to replace the toxicity response coefficient. The toxicity coefficient of heavy metal is Cu = 5, Zn = 1, Co = 5, Ni = 5, Cr = 2, Mn = 1, Pb = 5.

Health Risk Assessment Model (HI and CR)

The use of the United States Environmental Protection Agency (USEPA) health risk assessment model is an important method for assessing soil health risks [25]. In terms of carcinogenic and non-carcinogenic, it is an evaluation index that is comprehensively considered for adults and children from multiple intake routes. Because it considers the harm of heavy metals in soil to adults and children, it is widely used at present. The first step is to calculate the daily intake of each heavy metal in the sample from hand to mouth, respiratory system and skin. The calculation formula is as follows:

$$ADD_{ing} = \frac{C \times IR_{ing} \times EF \times ED}{BW \times AT} \times 10^{-6} \tag{7}$$

$$ADD_{inh} = \frac{C \times IR_{inh} \times EF \times ED}{BW \times AT \times PEF} \tag{8}$$

$$ADD_{dermal} = \frac{C \times SA \times SL \times ABS \times EF \times ED}{BW \times AT} \times 10^{-6} \tag{9}$$

ADD_{ing}, ADD_{inh} and ADD_{dermal} are the daily average exposure of heavy metals through hand-to-mouth inhalation, respiratory system inhalation and skin inhalation, mg/(kg·d). The corresponding parameter values (IR_{ing}, IR_{inh}, etc.) are shown in Table 3 below [26].

The non-carcinogenic health risk is the ratio of the average daily intake dose (ADD) of an element to the average daily reference dose (RfD). The calculation formula is as follows:

$$HI = \sum \frac{ADD_{jni}}{RfD_i} \tag{10}$$

$$THI = \sum HI \tag{11}$$

Table 3. Exposure model reference values.

Parameter	*Symbol*	Units	Adult	Child
Daily intake of soil in hand and mouth	IR_{ing}	mg/d	150	250
Respiratory rate	IR_{inh}	m^3/d	12.8	7.63
Exposure frequency	*EF*	days/year	180	180
Exposure duration	*ED*	years	24	6
Body weight	*BW*	kg	58.6	15
Averaging time	*AT* (Non-carcinogenic)	days	65700	2190
Averaging time	*AT* (carcinogenic)	days	25550	25550
Particle emission factor	*PEF*	m^3/kg	1.36E+09	1.36E+09
Skin surface area exposed	*SA*	cm^2	2145	1150
Adherence factor to skin	*SL*	mg/cm^3/day	0.07	0.2
Dermal absorption factor	*ABS*	-	0.001	0.001

Table 4. Reference doses and slope factors of heavy metals.

Element	RfD_{ora}/mg (kg d)$^{-1}$	RfD_{inh}/mg (kg d)$^{-1}$	RfD_{dermal}/ mg (kg d)$^{-1}$	SF_{ora}/kg d mg^{-1}	SF_{inh}/kg d mg^{-1}	SF_{dermal}/kg d mg^{-1}
Cu	0.037	0.04	0.04	-	-	-
Zn	0.3	0.3	0.3	-	-	-
Co	0.0003	0.00000571	0.016	-	9.8	-
Ni	0.02	0.0206	0.0054	-	0.901	-
Cr	0.003	0.0000255	0.000039	0.5	47	20
Mn	0.046	0.0000143	0.00184	-	-	-
Pb	0.0035	0.0052	0.0035	0.0085	0.042	0.0017

Where: HI is the non-carcinogenic risk of the i exposure route of t source element n in sample j.

The carcinogenic risk is the product of the average daily intake dose (ADD) of an element and the carcinogenic slope factor (SF) of that element. The calculation formula is as follows:

$$CR = \sum ADD_{jni} \times SF_i \quad (12)$$

$$TCRI = \sum CR \quad (13)$$

Where: CR is the carcinogenic risk of the i exposure route of t source element n in sample j. The corresponding parameter values (RfD_i, SF_i) are shown in Table 4.

Results and Discussion

Content and Spatial Distribution Characteristics of Heavy Metals in Soil

Characteristics of Heavy Metal Content in Soil

In this paper, a total of seven heavy metal elements, Cu, Zn, Co, Ni, Cr, Mn and Pb, were selected to analyze the vegetable base in the region, and the content characteristics of heavy metal test results at 36 sampling points were analyzed. See Table 5 [27-28] for the statistical value of heavy metal content in the soil of the study area, and see Fig. 2 for the statistical histogram of heavy metal content in various vegetable bases.

According to the data in the table, the average content of the seven heavy metal elements measured is Mn>Pb>Zn>Cr>Ni>Cu>Co from the largest to the smallest, of which the highest average content is Mn element, 701.18 mg. Kg^{-1}; The least is Co element, which

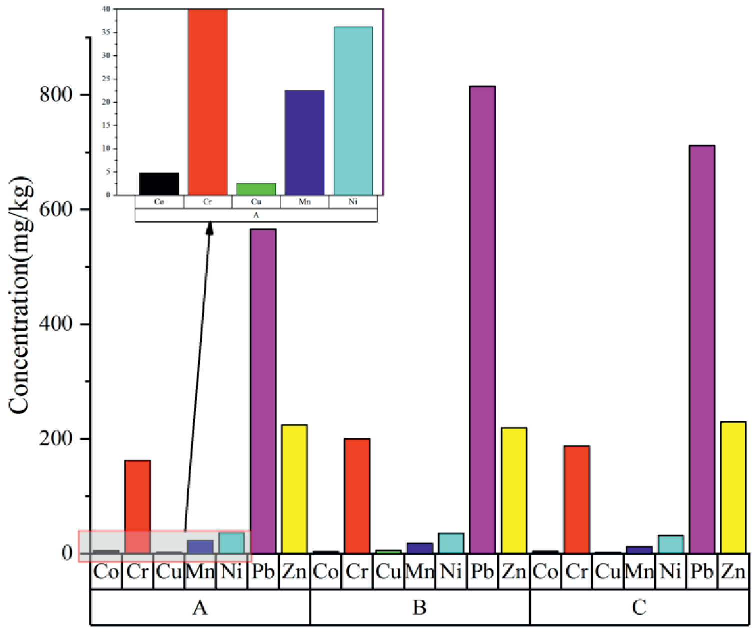

Fig. 2. Concentrations of heavy metals in soil of three lands.

is 2.90 mg. $Kg^{-1.}$ Compared with the background value of soil in Anhui Province, the mean values of Pb, Zn and Mn exceed the standard, and are 8.47, 2.98 and 1.32 times of the background value of Anhui Province. In all sampling points, the exceeding rate of elements from small to large is $Cr<Cu<Co<Ni<Mn<Zn<Pb$, in which Pb and Zn elements all exceed the standard, 83.3% of Mn elements exceed the standard, 19.44% of Ni elements exceed the standard, 2.78% of Co elements exceed the standard, while Cu and Cr elements do not exceed the standard. The above analysis shows that Pb, Zn, Mn, Ni and Co have been polluted to different degrees in the vegetable park, among which Pb, Zn and Mn are seriously polluted, and Ni and Co are relatively

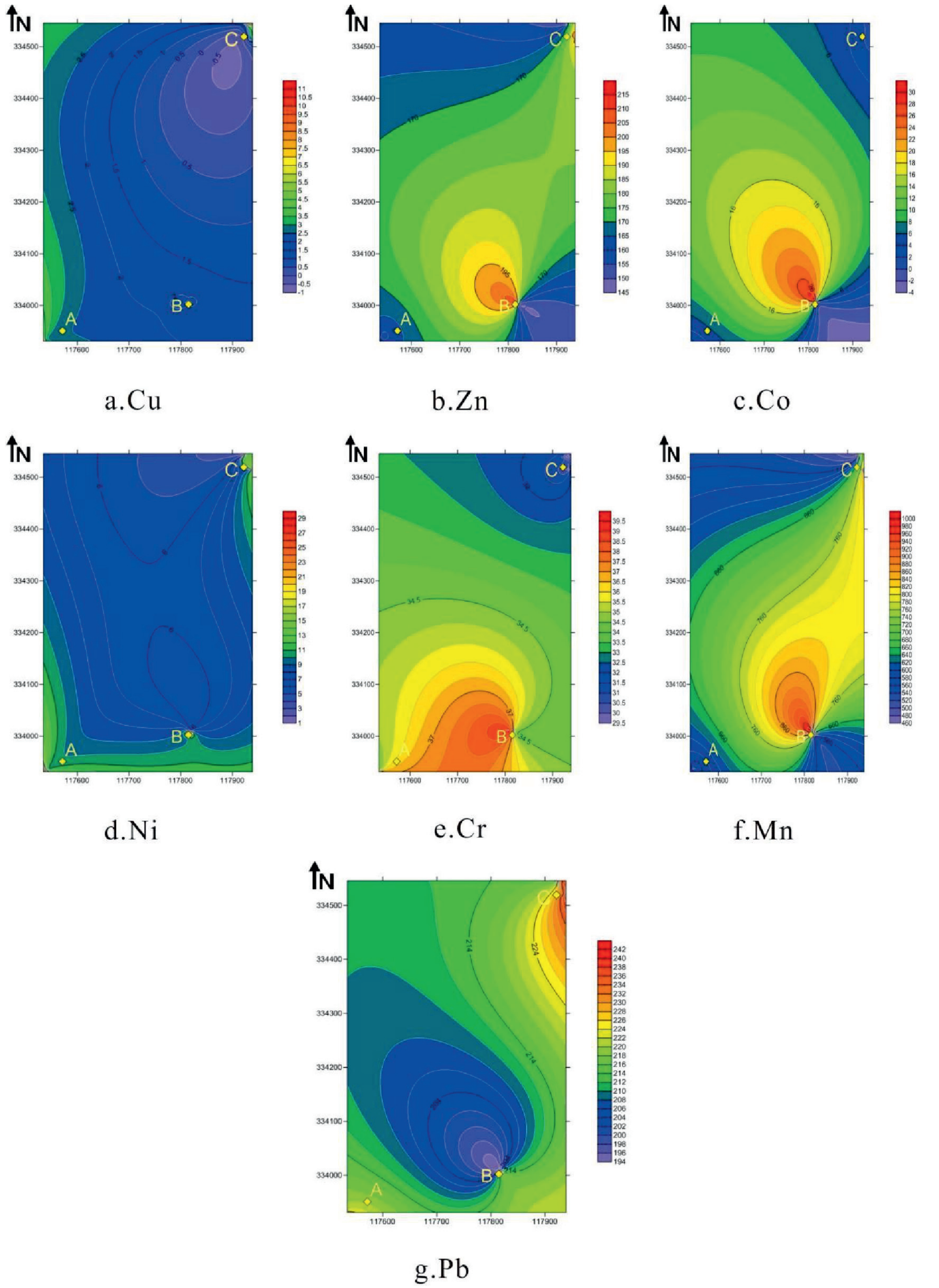

Fig. 3. Regional Spatial distribution of heavy metals in soil.

low, which may be affected by human factors.

Compared with the risk screening value of the Standard for the Control of Soil Pollution Risk of Agricultural Land (Trial) (GB 15618-2018), the maximum content of Pb was 1.41 times of the screening value, and the maximum content of other elements did not exceed the screening value. The average value of (Pb) is 1.33 times of the screening value, and the average value of other elements does not exceed the screening value. The proportion of Pb exceeding the standard value samples in soil was 100.00%, and the other elements did not exceed the standard. It can be seen that Pb may be the main heavy metal pollutant in the soil of the study area.

Coefficient of variation (CV) is a numerical value that describes the fluctuation of data. As shown in the table, the variation coefficients of heavy metals are Co>Cu>Ni>Mn>Zn>Cr>Pb from large to small. According to Wilding's classification of variation degree, three elements of high variation type (CV>36%) are Co, Cu and Ni (214.32%, 67.03%, 53.87%). Only Mn (21.47%) was found in moderate variation type (15%<CV>36%); The remaining three elements Zn, Cr and Pb (13.99%, 8.56% and 4.64%) are of low variation type (CV<15%). From the perspective of variation coefficient, Co, Cu and Ni in soil are of high variation type, indicating that the data distribution has great spatial dispersion, and these three elements may be affected by strong external factors.

Spatial Distribution Characteristics of Heavy Metals in Soil

Due to the influence of soil characteristics and agricultural production activities, the content of heavy metals in the soils of the three vegetable bases in the region is not significantly different. According to the spatial distribution data of different elements in the study area, see Table 5, and use the buffer software to draw the contour map, see Fig. 3. The analysis results are as follows:

A is located in the southwest corner of the figure, B is located in the south by east of the figure, and C is located in the northeast of the figure. As shown in Fig. 2(a-f), A is at the edge. Comparing with the surrounding contour lines, it can be seen that the contents of Cu, Ni

Table 5. Descriptive statistics of heavy metals in soils under vegetable base.

Sampling point		Cu	Zn	Co	Ni	Cr	Mn	Pb
Vegetable field A	Max	6.85	175.19	2.86	30.98	37.58	643.29	231.17
	Min	2.48	146.18	2.21	10.84	34.3	516.31	218.38
	Mean	4.77	162.77	2.50	22.57	36.19	566.14	224.16
	SD	1.69	8.18	0.26	6.14	1.11	35.93	3.76
Vegetable field B	Max	8.28	226.04	38.89	32.06	40.45	1122.05	237.55
	Min	2.05	146.33	0.12	4.61	32.01	516.14	190.94
	Mean	3.36	199.89	5.44	17.68	35.36	815.09	219.42
	SD	1.80	23.53	11.86	8.52	2.22	160.48	12.83
Vegetable field C	Max	11.87	242.54	3.29	27.11	34.87	918.69	240.29
	Min	1.11	140.75	0.89	0.00	28.22	496.53	212.62
	Mean	4.11	187.61	1.84	11.95	31.31	711.75	229.20
	SD	3.35	24.99	0.73	7.27	1.71	122.08	9.55
Vegetable field	Min.	11.1	140.75	0.12	0	28.22	496.53	190.94
	Max.	11.87	242.54	38.89	32.06	40.45	1122.05	240.29
	Mean.	4.09	184.47	2.90	16.04	33.54	701.18	225.49
	SD.	2.74	25.81	6.22	8.64	2.87	150.55	10.46
	CV.	67.03%	13.99%	214.32%	53.87%	8.56%	21.47%	4.64%
BV[a]		20.4	62	16.3	23.44	66.5	530	26.6
PRV[b]		100	300	-	190	250	-	170

SD equal to standard deviation.
CV equal to coefficient of variation.
BV[a] equal to soil background value in Anhui province [27].
PRV[b] equal to GB15618-2018-Soil environmental quality-standard for soil pollution risk control of agricultural land [28].

and Cr in this area are higher than those in other areas, while the contents of Zn, Co, Mn and Pb in the three areas are closer to the median; Land B is surrounded by contour lines in Fig. 2(a-f), which indicates that the content of Cu, Zn, Co, Ni, Cr and Mn in the land is higher than that in the surrounding area, and that of Zn, Co and Mn are higher than those in other places, while Fig. 2g) shows that the content of Pb in the land is lower than that in other two places; Area C is surrounded by isopleth in Fig. 2(a, b, f and g), indicating that the content of Cu, Zn, Mn and Pb in this area is higher than that in the surrounding area, and the Pb element in this area is higher.

Potential Ecological Risk Analysis

Pollution Index Evaluation of Heavy Metals in Soil

Fig. 4 (a and b) shows the enrichment of heavy metals (EF) in the soils of the three study areas, indicating that different elements have different degrees of accumulation in the area. The EF values of Zn and Pb in the three study areas are greater than 1, and the enrichment degree is 100%. Among them, 44.44% of Zn elements are at medium enrichment level (2<EF<5) and 55.56% are at slight enrichment level (1<EF<2); 93.22% of Pb elements are at a relatively serious enrichment level (5<EF<20). In addition, the enrichment degree of Mn is 61.11%; The enrichment degree of Co is 2.78%; The EF values of the remaining three elements, Cu, Ni and Cr, are all below 1 and are not enriched.

Fig. 4c) shows the corrected pollution index (MPI) of heavy metals in different soils of different research areas, showing the pollution level of the area. Among them, Cr, Cu and Ni are at the pollution-free level (MPI<1); Co only reached slight pollution level (1<MPI<2) in study area C; Mn is at slight pollution level (1<MPI<2); Zn in study area B reached medium to serious pollution level (3<MPI<5), and the other two study areas were at medium pollution level (2<MPI<3); Pb is at serious pollution level (5<MPI<10). It shows that there is no Cr, Cu and Ni pollution in this area, but slight Co and Mn pollution and moderate Zn pollution, of which Pb heavy metal pollution is the most severe and needs to be strictly controlled.

Ecological Risk Assessment of Heavy Metals in Soil

Fig. 5 shows the assessment of pollution in the study area based on the content of heavy metals in the soil using the single factor index method. The cleaning degree of various heavy metals is Cu, Mn, Cr, Co, Ni, Zn and Pb. Only Cu and Mn are clean (P_i<0.7), while Cr, Co and Ni are slightly polluted (1<P_i<2), in which the Nemero comprehensive pollution assessment of Pb and Zn is 8.76 and 3.48 respectively are seriously polluted (P_i>3). The results show that Pb pollution is the most serious in the study area, and Zn pollution is relatively serious. It is necessary to pay attention to these two heavy metals.

The single-factor potential ecological risk assessment of different elements is shown in Table 6. This table

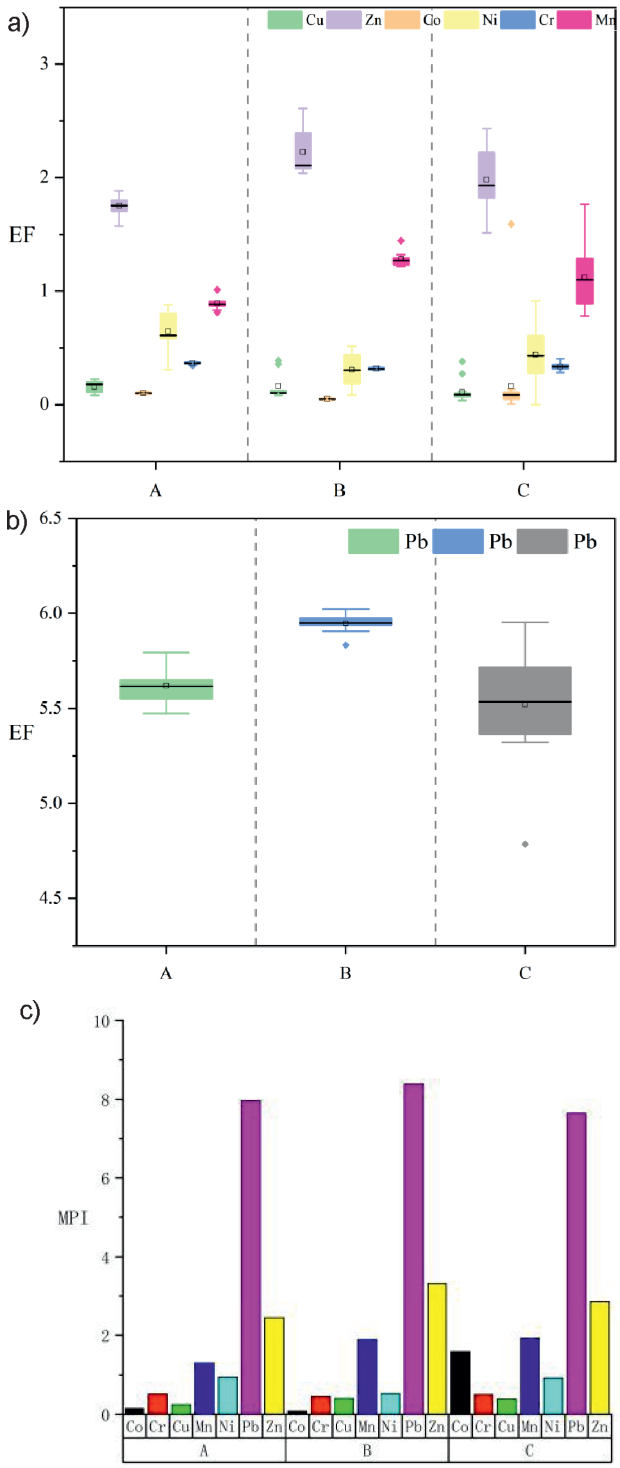

Fig. 4. EF (a and b) and MPI c) of heavy metals in soil. a) Enrichment factor of Cu, Zn, Co, Ni, Cr and Mn in soil (EF); b) Enrichment factor of Pb in soil; c) Modified pollution index of heavy metals in soil (MPI).

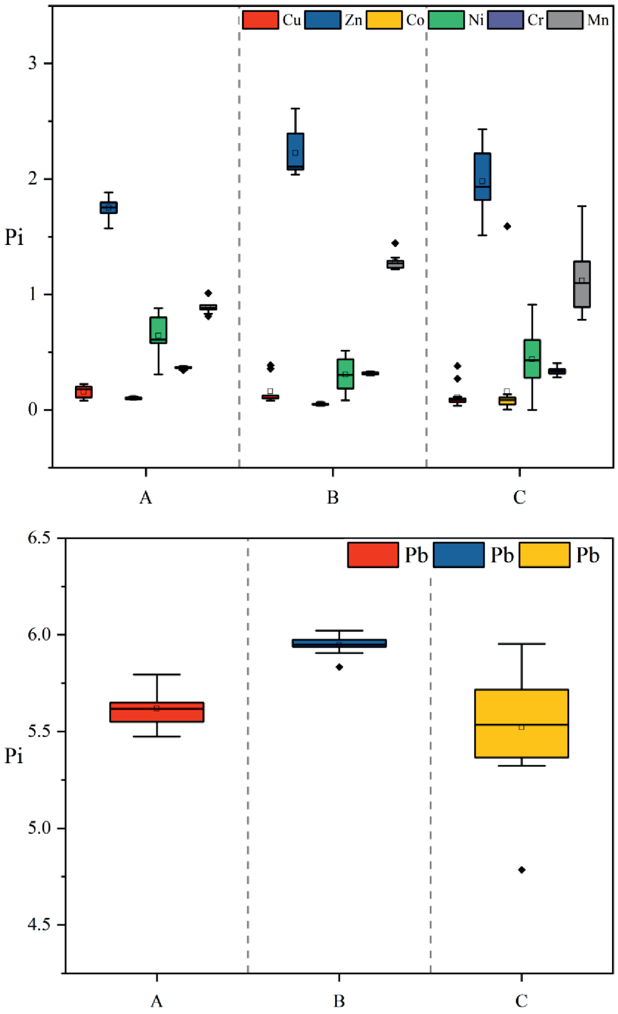

Fig. 5. Box diagram of single factor index method for heavy metal elements.

summarizes values of different elements in three vegetable bases. The single factor potential risk index of different heavy metal elements is Pb, Ni, Zn, Cu, Mn, Cr, Co from high to low. And there are slight potential risks (<40).

Health Risk Assessment of Heavy Metals in Soil

Use the health risk assessment model and relevant parameters to calculate the maximum, minimum and average values of six heavy metals in the soil of different regions to calculate the risk values of three exposure routes (including oral intake, oral and nasal inhalation and skin exposure), as shown in Tables 6, 7 and Fig. 6.

According to USEPA standards, the maximum acceptable THI is 1. If THI<1 means there is no non-carcinogenic risk, and THI>1 means there is a non-carcinogenic risk. Table 7 shows that the adult's THI is from 7.6E-01 to 1.8E+00 for adults and from 7.8E-01 to 1.9E+00 for children, indicating that the region has the same degree of non-carcinogenic risk for adults and children: only the maximum THI value of the two in Zone C exceeds the standard, indicating that there is a non-carcinogenic risk. However, different exposure routes have different effects on adults and children: for adults, inhalation through hands and mouth is the most serious exposure route, while for children, skin contact intake route.It is worth noting that there are more than standard samples in HIdermal, indicating that there are some serious non-carcinogenic risks in the way of skin inhalation intake in the research field. As shown in Fig. 6(a, b), the THI of the three regions is similar in the order of adults and children, A<B<C, which means that C is the main region to reduce pollution and protect human health risks.

As shown in Table 8, in terms of cancer risk, the TCRI values of adults are 1.13E-05--1.54E-05 and children are From 1.17E-05 to 1.59E-05. For adults, hand and mouth inhalation is the main route of exposure to cancer in this area, and the CR value of this route is between 6.97E-06 and 9.46E-06. For children, skin contact is the main exposure route of cancer in this area, ranging from 7.25E-06 to 9.87E-06. Therefore, adults should pay more attention to hand and mouth inhalation,

Table 6. Evaluation of potential ecological (E_r^i) of heavy metals in soils.

Sampling point		Cu	Zn	Co	Ni	Cr	Mn	Pb
Vegetable field A	Max.	1.12	1.88	0.58	4.41	0.75	1.01	28.97
	Min.	0.41	1.57	0.45	1.54	0.69	0.81	27.37
	Mean.	0.78	1.75	0.51	3.21	0.73	0.89	28.09
Vegetable field B	Max	1.94	2.61	0.67	3.86	0.70	1.44	30.11
	Min	0.18	1.51	0.18	0.00	0.57	0.78	26.64
	Mean	0.67	2.02	0.38	1.70	0.63	1.12	28.72
Vegetable field C	Max	0.05	2.43	7.95	4.56	0.81	1.76	29.77
	Min	0.01	1.57	0.02	0.66	0.64	0.81	23.93
	Mean	0.55	2.15	1.11	2.51	0.71	1.28	27.50

Table 7. Descriptive statistics of HI and THI for Non-Carcigenic risk.

		Audults				Children			
		HIing	HIinh	HIdermal	THI	HIing	HIinh	HIdermal	THI
Vegetable field A	Max	1.7E-02	4.9E-04	3.0E-04	8.3E-01	8.6E-03	1.3E-02	1.8E-02	8.5E-01
	Min	1.6E-02	4.0E-04	2.9E-04	8.0E-01	7.0E-03	1.3E-02	1.7E-02	8.2E-01
	Avage	1.7E-02	4.4E-04	2.9E-04	8.1E-01	7.7E-03	1.3E-02	1.7E-02	8.3E-01
Vegetable field B	Max	1.8E-02	6.9E-04	2.9E-04	8.6E-01	1.2E-02	1.3E-02	1.9E-02	8.9E-01
	Min	1.6E-02	3.9E-04	2.5E-04	7.6E-01	6.7E-03	1.1E-02	1.6E-02	7.8E-01
	Avage	1.7E-02	5.4E-04	2.7E-04	8.1E-01	9.5E-03	1.2E-02	1.7E-02	8.3E-01
Vegetable field C	Max	3.8E-02	9.2E-04	1.4E-03	1.8E+00	7.8E-03	1.3E-02	1.7E-02	1.9E+00
	Min	1.6E-02	4.0E-04	2.5E-04	7.8E-01	7.5E-03	1.3E-02	1.7E-02	8.0E-01
	Avage	1.9E-02	6.3E-04	4.0E-04	9.2E-01	7.6E-03	1.3E-02	1.7E-02	9.5E-01
		3.8E-02	9.2E-04	1.4E-03	1.8E+00	1.2E-02	1.3E-02	1.9E-02	1.9E+00
		1.6E-02	3.9E-04	2.5E-04	7.6E-01	6.7E-03	1.1E-02	1.6E-02	7.8E-01

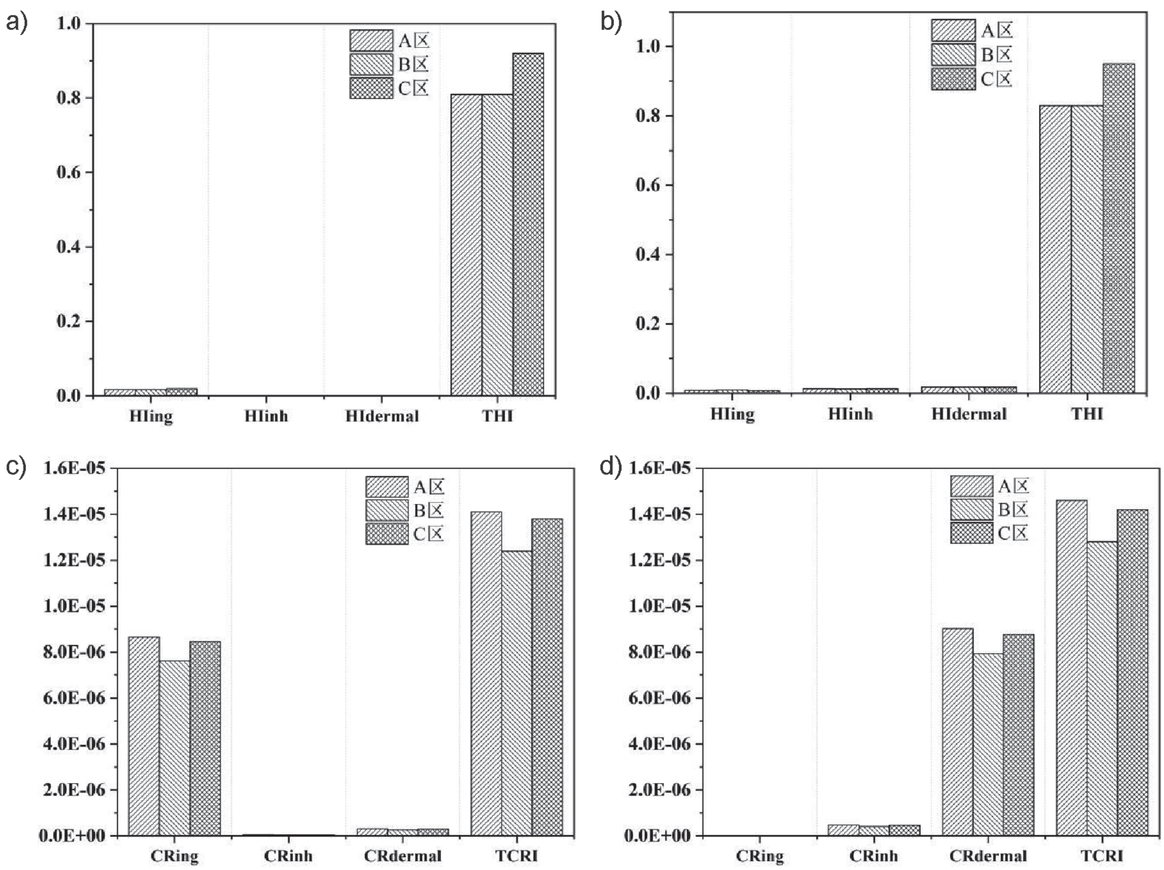

Fig. 6. Bar chart of carcinogenic and non-carcinogenic children and adults in different regions.

and children should pay more attention to skin contact. For adults and children, the cancer risk of TCRI in the three regions maintained the same trend: B<C<A. It can be seen from Fig. 6(c, d) that Area A is the most important and priority area of heavy metal carcinogenic risk in this research field.

Conclusions

In this paper, the vegetable garden in the north of Suzhou City was tested, and the enrichment status and potential risks of heavy metals in soil were evaluated by using the soil heavy metal pollution index evaluation

Table 8. Descriptive statistics of CR and TCRI for Carcigenic risk.

		Audults				Children			
		CRing	CRinh	CRdermal	TCRI	CRing	CRinh	CRdermal	TCRI
Vegetable field A	Max	8.96E-06	4.93E-08	3.26E-07	1.46E-05	2.96E-17	4.87E-07	9.33E-06	1.51E-05
	Min	8.26E-06	4.53E-08	2.97E-07	1.34E-05	2.49E-17	4.45E-07	8.60E-06	1.39E-05
	Avage	8.66E-06	4.77E-08	3.14E-07	1.41E-05	2.76E-17	4.69E-07	9.02E-06	1.46E-05
Vegetable field B	Max	8.35E-06	4.61E-08	3.02E-07	1.36E-05	2.57E-17	4.52E-07	8.70E-06	1.40E-05
	Min	6.97E-06	3.69E-08	2.45E-07	1.13E-05	1.71E-17	3.66E-07	7.25E-06	1.17E-05
	Avage	7.62E-06	4.10E-08	2.71E-07	1.24E-05	2.09E-17	4.06E-07	7.93E-06	1.28E-05
Vegetable field C	Max	9.46E-06	6.26E-08	3.51E-07	1.54E-05	4.01E-17	5.25E-07	9.87E-06	1.59E-05
	Min	7.74E-06	4.15E-08	2.78E-07	1.26E-05	2.16E-17	4.15E-07	8.06E-06	1.30E-05
	Avage	8.46E-06	4.73E-08	3.07E-07	1.38E-05	2.69E-17	4.56E-07	8.77E-06	1.42E-05
		9.46E-06	6.26E-08	3.51E-07	1.54E-05	4.01E-17	5.25E-07	9.87E-06	1.59E-05
		6.97E-06	3.69E-08	2.45E-07	1.13E-05	1.71E-17	3.66E-07	7.25E-06	1.17E-05

method, single factor pollution index, potential ecological risk evaluation method and health risk evaluation method. The results are as follows:

(1) Compared with the background value of Anhui Province, the heavy metal content of Pb, Zn, Mn, Ni and Co in the soil of the vegetable garden is higher than the background value. Among them, Pb and Zn all exceed the standard, 83.3% of Mn, 19.44% of Ni and 2.78% of Co exceed the standard.

(2) According to the single-factor pollution assessment results, only Cu and Mn are clean, Cr, Co and Ni are light pollution, and Pb and Zn are heavy pollution, which provides some reference for growers and managers to the heavy metal pollution in the area.

(3) According to the results of potential ecological risk assessment, the study area is dominated by mild ecological risk, and the number of soil samples with moderate ecological risk accounts for 9.77%.

(4) According to the health risk indicators, there is a non-carcinogenic risk in the way of skin inhalation intake, and Zone C is the main area to reduce pollution to protect human non-carcinogenic health risk. For the carcinogenic risk, attention should be paid to the hand and mouth inhalation of adults and the skin contact of children. Zone A is the most important and priority area of heavy metal carcinogenic risk in this research area.

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Conflict of Interest

The authors declare no conflict of interest.

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