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Evaluation of heavy metal contamination of soil in a planting area in Hengshui City, Hebei Province

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Abstract: *To understand the characteristics of soil heavy metal pollution in a planting area of Hengshui City, Hebei Province, 340 samples were tested and analyzed by using the ground accumulation index, Nemero comprehensive pollution index, potential ecological risk index and enrichment factor for comprehensive evaluation. The results showed that the average value of* I_{geo} *was less than 0, and the order of weakness to strength was* $As<Cr<Ni<Cu<Cd<Zn<Pb<Hg$*, among which the number of samples with Hg* I_{geo} *was 36.44%; the overall environmental safety was relatively low with PN; the exceedance rate of the total potential ecological risk index (RI) was 25.24%. 25.24%; the mean value of enrichment factor (EF) was less than 2, and the percentage of samples in the state of no to weak pollution was over 74.76%.*

Keywords: *planting area; soil heavy metals; ecological risk; ground accumulation index*

1. Introduction

Soil is the basis for the existence of all living things, and the good or bad soil environment directly affects the health of plants and animals and human beings, especially the soil in planting areas is closely related to the agricultural planting environment and is concerned with human health [1]. High-quality land resources are an important carrier for the development of the agricultural industry in Hebei Province and a material basis for the survival and development of human beings [2]. With the continuous development of modern agricultural technology, pesticides and fertilizers are used in large quantities in planting, and some agricultural land soils have different degrees of organic and inorganic contamination, among which heavy metal pollution is especially prominent. Heavy metal is an important pollutant of agricultural environment and agricultural products, because the natural purification process of heavy metal in the soil is very long, so its pollution is hidden, irreversible and long-term, it is in the plant roots, stems, leaves and seeds in a large number of accumulation, not only seriously affect the growth and development of plants, but also through the food chain to people or animals, bringing serious harm to human health. However, so far there are few comprehensive studies on the ecological risk of soil heavy metals at the scale of Hengshui planting area, and the level of soil heavy metal pollution, ecological risk magnitude and health risk degree are unclear, thus there is an urgent need to conduct soil heavy metal risk studies.

2. Materials and Methods

2.1 Overview of the study area

Hengshui is located between 115°10'~116°34'E and 37°03'~38°23'N. It is situated in the southeastern part of the North China Plain, with the topography sloping from southwest to northeast and the elevation between 12 m and 30 m. The total area of Hengshui is 8815 km^2 and the resident population is 4.34 million. In recent years, the economy of Hengshui has been developing rapidly. The soil is mostly tidal loam, two-combined soil and sandy loam, which is fertile and moderate in texture. The main food crops are wheat, corn, grain and sorghum, and the main cash crops are cotton, peanuts, sesame and sunflower.

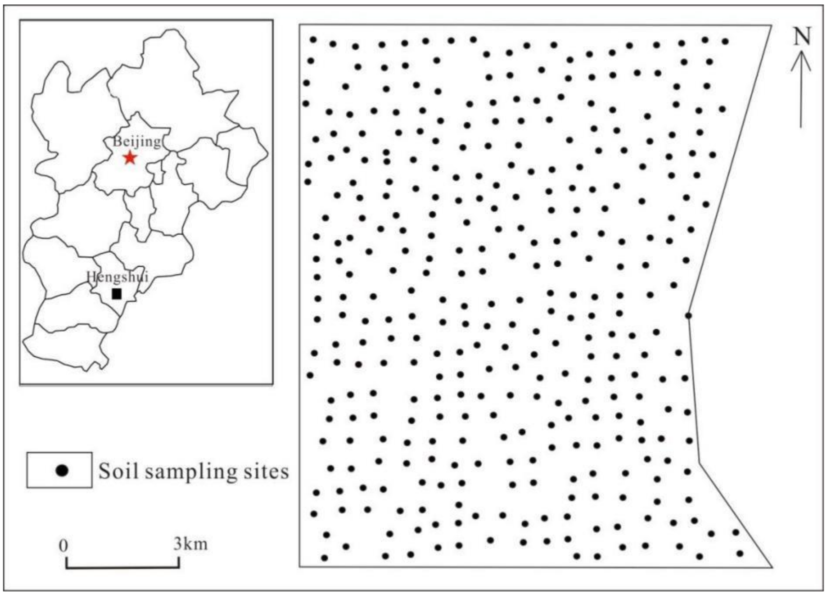

Figure 1: Distribution map of surface soil sampling points in the study area

2.2 Sample collection and processing

In this study, a total of 340 pieces of surface soil samples were collected from April to June 2020 at a sampling depth of 0~20 cm (Figure 1). The sampling density was about 3~5 pieces/km^2, and each sample was made up of one central point and four sub-sample points of equal weight. On the premise of ensuring the basic consistency of soil types in each sub-sample point, we tried to avoid plots that might cause contamination to the samples, such as garbage soil, serious soil erosion or topsoil that had obviously been destroyed, etc. The distance of sub-sample points from the central point was not less than 80 m, and the original weight of the sample was more than 1kg. The samples were collected with a wooden shovel during the sampling process. After the samples were collected, they were dried naturally and passed through a nylon sieve with an aperture of 40 mesh, and then passed through a nylon sieve with an aperture of 100 mesh after being processed by a ball and star mill.

2.3 Sample analysis testing and quality control

Soil sample analysis tests included cadmium (Cd), chromium (Cr), copper (Cu), manganese (Mn), nickel (Ni), lead (Pb), scandium (Sc), titanium (Ti), zinc (Zn), iron trioxide (Fe_2O_3), arsenic (As), mercury (Hg), and pH indicators. The samples were analyzed by the relevant methods in the Regional Geochemical Sample Analysis Methods, inductively coupled plasma mass spectrometry for Cd, inductively coupled plasma emission spectrometry for Cr, Cu, Mn, Ni, Pb, Sc, Ti, Zn and Fe_2O_3, hydride-atomic fluorescence spectrometry for As, and cold vapor-atomic fluorescence spectrometry for the determination of Hg in soil samples, and ion selective electrode method for the determination of pH in soil samples. Three national standard soil samples were used to monitor the accuracy of the analytical tests in the laboratory. The accuracy (RE) was obtained by inserting the test results for the coded sample (7%) from the national standard, and the precision of the test (RD) was assessed by the results of the duplicate sample (5%) analysis.

3. Evaluation Methodology

In this study, the risk control standard for soil pollution on agricultural land for soil environmental quality (GB 15618-2018) and the geochemical parameter values of surface soil (0-20 cm) in Hebei Province (lower volume) [3] were used as the reference values for the evaluation of the background values of surface soil in Hengshui City. At present, there are many methods to evaluate soil heavy metal pollution, and so far there are no unified regulations and standards, and various pollution evaluation methods have certain limitations and shortcomings [4], and it is impossible to obtain comprehensive results using a single evaluation method. Therefore, considering the functional attributes of this study area, four methods such as ground accumulation index, Nemero comprehensive pollution index, potential ecological risk index and enrichment coefficient were used for

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comprehensive evaluation, and their mutual complementation will make the evaluation results more accurate, in order to improve the shortcomings of the research on soil heavy metal pollution in this area, and provide a reliable scientific basis for the prevention and remediation of soil heavy metal pollution, ecological environmental protection and healthy living of residents in Hengshui. We hope to improve the shortage of research on soil heavy metal pollution in Hengshui and provide a reliable scientific basis for the prevention and remediation of soil heavy metal pollution, ecological protection and healthy living of residents.

3.1 Ground accumulation index

The index of geoaccumulation (Index of geoaccumulation), also known as the Muller index, is an evaluation method proposed by the German scientist G. Müller to study the quantitative indicators of heavy metal pollution in soil [5], and in recent years it has been widely used by experts and scholars at home and abroad to evaluate the pollution of soil (sediment) by heavy metals generated by human activities [6]. The calculation formula is:

$$I_{geo} = \log_2[\frac{C_s^i}{\mathrm{K} \times C_n^i}] \tag{1}$$

where: I_{geo} denotes the physical ground accumulation index of heavy metal i; Ci s denotes the measured value of heavy metal i in soil (mg/kg); Ci n denotes the background value of heavy metal element i (mg/kg); K denotes the correction coefficient (generally taken as 1.5); in this study, the values of geochemical parameters of surface soil (0-20) in Hebei Province [3] were used as the background values of soil in this study area; the ground accumulation The grading criteria of the index are shown in Table 1.

Table 1: Classification standard of geoaccumulation index

I_{geo}	Grading	Pollution level
$I_{geo} \leq 0$	0	Non-polluting
$0 < I_{geo} \leq 1$	1	Light to medium pollution
$1 < I_{geo} \leq 2$	2	Moderate pollution
$2 < I_{geo} \leq 3$	3	Moderate - strong pollution
$3 < I_{geo} \leq 4$	4	Strong pollution
$4 < I_{geo} \leq 5$	5	Strong - Very Severe Pollution

3.2 Nemero Composite Pollution Index

Nemerow integrated pollution index method was proposed by Nemerow [7], this method is widely used in China [8-9] because it not only reflects the effect of each pollutant on the soil, but also highlights the effect of high concentration of pollutants on soil environmental quality, calculated by the formula

$$P_i = {}^{C_i}/_{C_0} \tag{2}$$

$$P_N = \sqrt{\frac{(P_{iave})^2 + (P_{imax})^2}{2}} \tag{3}$$

Where: P_i denotes the single pollution index of heavy metal i; C_i denotes the measured concentration of heavy metal i (mg/kg); C_0 denotes the evaluation standard of heavy metal i; P_N denotes Nemero comprehensive pollution index; P_{iave} denotes the arithmetic mean of P_i value of each element, and P_{imax} denotes the maximum value of P_i value of each element; the evaluation standard of each heavy metal in soil adopts the screening value in GB 15618 -2018 in the screening value; according to the P_N value, the pollution levels are divided into safe ($P_N \leq 0.7$), alert ($0.7 < P_N \leq 1.0$), light pollution ($1.0 < P_N \leq 2.0$), moderate pollution ($2.0 < P_N \leq 3.0$), and heavy pollution ($P_N > 3.0$).

3.3 Potential ecological risk index

The potential ecological risk index (*RI*) evaluation method is a widely used method today to

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evaluate soil heavy metal pollution and ecological hazards proposed by the famous Swedish scholar Lars Hakanson in 1980 [10], which not only combines the toxicological coefficients of each heavy metal, but also relates the ecological, environmental and toxicological effects of each heavy metal element, using a comparable index grading method with equivalence properties It is a widely used method for ecological risk assessment today [11]. The calculation formula is.

$$E(i) = T_i \times \frac{C_i}{C_0} \tag{4}$$

$$RI = \sum_{i=1}^{n} E(i) \tag{5}$$

Where: *Ei* denotes the single coefficient of potential ecological risk of soil heavy metal element i; Ti denotes the toxic response coefficient of soil heavy metal element *i*; C_i denotes the measured concentration of surface soil heavy metal element i (mg/kg); C_0 denotes the regional soil background value (mg/kg); RI denotes the total potential ecological risk index (the sum of single potential ecological risk *Ei*); since this study area is located in Hengshui city area, the geochemical parameter values of surface soil (0-20) in Hebei province [3] were used as the background values of surface soil in this study area; the toxicity response coefficients of each heavy metal (Hg=40, Cd=30, As=10, Cu=Ni=Pb=5, Cr=2, Zn=1); the classification criteria of each index are shown in Table 2.

Table 2: Classification standard of ecological risk index Ei and RI

Ei	Ecological risk of single-factor pollution	*RI*	Potential ecological hazard level
<40	Minor	<150	Minor
40 ≤*Ei* <80	Moderate	150≤*RI*< 300	Moderate
80≤*Ei*<160	Stronger	300≤*RI*< 600	Strong
160≤*Ei* <320	Strong	≥600	Very strong
≥320	Very strong	—	—

3.4 Enrichment factors

The Enrichment Factor (EF) method is a parameter to evaluate the influence of human activities on the degree of enrichment of heavy metals in soil (sediment) [12] and an important indicator to determine the level of contribution to the enrichment of heavy metals in soil (sediment) [13]. The enrichment factor is the ratio of the measured content of elements in the sample to the reference element content to the ratio of the two in the background area and is calculated as.

$$EF = \frac{(C_i/C_n)_{sample}}{(C_i/C_n)_{baseline}} \tag{6}$$

Where: EF denotes the enrichment factor; Ci denotes the content of element i in the soil; Cn denotes the content of the selected reference element; sample and baseline denote sample and background, respectively. Al, Ti, Sc, Mn, Fe, and Ca, which are geochemically stable and not easily influenced by human activities, are often selected as reference elements originating from the surface layer of the earth's crust [14-15], and the correlation between the contents of eight heavy metals and reference elements in soil can be used to determine whether the heavy metal elements in soil are influenced by human activities with reasonableness. According to the grading criteria of Southerland [16], the heavy metal pollution enrichment factor was divided into five levels, EF < 2 (no~weak pollution); 2 < EF < 5 (moderate pollution); 5 < EF < 20 (significant pollution); 20 < EF < 40 (high pollution); EF > 40 (extreme pollution); when EF > 1, it means that the relative enrichment of the element is influenced by human activities .

3.5 Data analysis and graphing

Statistical analysis of the data was performed using software such as Excel 2017 and SPSS 19. Corel DRAW 2018 was used for graphing, and SPSS 19 was used for statistical analysis of data such as

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minimum, maximum, mean, median, coefficient of variation and correlation of elements.

4. Results and Discussion

4.1 Soil heavy metal content characteristics

The mean and median values of soil pH were higher than the background values of surface soils in Hebei Province; the median values of soil heavy metals As, Cd, Cr, Cu, Hg, Ni, Pb and Zn were 8.19, 0.152, 55.7, 24.7, 0.115, 25.2, 26.5, 76.7 and 8.60 mg/kg, respectively, see Table 3. The coefficient of variation is a quantitative indicator to evaluate the degree of spatial variability of soil characteristics parameters, and the larger the coefficient of variation, the more heterogeneous and discrete the distribution of elements [17]. Hg has the highest coefficient of variation of 220.59% and the highest inhomogeneity, and may be most seriously affected by human activities, while heavy metals Cd, Cu, Ni, Pb and Zn are moderately variable, and Cr has the lowest coefficient of variation and may be least affected by human activities; in general, the high coefficient of variation and high content imply that soil heavy metals in the study area are locally intervened by human activities.

According to GB 15618-2018 standard and shown in Figure 2, the contents of Cd, Cr, Cu, Hg, Ni, Pb and Zn in all soil samples are less than the risk screening value of soil pollution in agricultural land, which is a safe and non-polluting grade; there is only one soil sample with As content exceeding the risk screening value of soil pollution in agricultural land, but not exceeding the risk control value of soil pollution in agricultural land.

Table 3: Characteristics of heavy metal content in surface soil of the study area

Projects	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	pH
Minimum value	2.98	0.061	41.3	12.3	0.014	16.2	15.9	45.8	7.77
Maximum value	43.81	0.301	82.6	67.2	0.964	42.8	54.5	225.1	9.15
Average value	7.66	0.152	56.1	23.6	0.068	25.7	25.3	73.0	8.62
Median value	8.19	0.152	55.7	24.7	0.115	25.2	26.5	76.7	8.60
Standard deviation	4.04	0.07	6.23	7.79	0.15	4.27	5.96	22.76	0.26
Coefficient of variation (%)variation (%)	52.74	46.05	11.11	33.01	220.59	16.61	23.56	31.18	3.02
Screening values for agricultural land [9]	25	0.6	250	100	3.4	190	170	300	—
Soil background values[17]	8.4	0.094	68.3	21.8	0.057	30.8	21.5	78.4	8.11

Note: "-" means not mentioned, elemental content unit is mg/kg, pH is dimensionless.

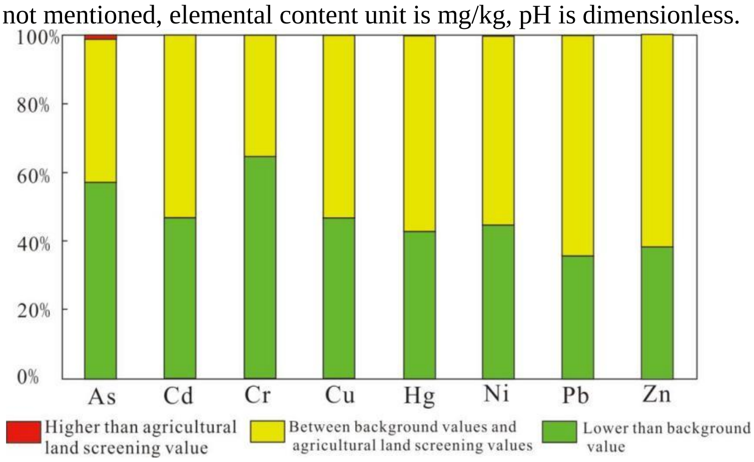

Figure 2: Graded proportion map of heavy metal elements in soil of the study area

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4.2 Soil heavy metal land accumulation index

The evaluation results of the surface soil heavy metal ground accumulation index showed that the average value of soil heavy metal ground accumulation index (I_{geo}) was less than 0; the average value of I_{geo} was As<Ni<Cu<Cd<Zn<Pb, see Table 4.

Table 4: Geo-accumulation index statistics of heavy metals in surface soil of the study area

chemical element	I_{geo} Scope	I_{geo} Average value	The proportion of samples with different pollution levels of elements/%(n=340)						
			Non-polluting	Light pollution	Medium pollution	Medium to heavy pollution	Heavy pollution	Heavy to very heavy pollution	Very heavy pollution
As	-2.06~1.80	-0.69	98.14	0.93	0.93	0	0	0	0
Cd	-1.76~0.50	-0.54	86.92	13.08	0	0	0	0	0
Cr	-1.02~-0.09	-0.64	100	0	0	0	0	0	0
Cu	-1.44~0.91	-0.55	92.52	7.48	0	0	0	0	0
Hg	-2.41~3.44	-0.20	63.56	16.82	14.02	4.67	0.93	0	0
Ni	-1.32~0.14	-0.61	99.07	0.93	0	0	0	0	0
Pb	-1.16~0.65	-0.45	93.46	6.54	0	0	0	0	0
Zn	-1.15~1.13	-0.48	92.53	6.54	0.93	0	0	0	0

4.3 Soil heavy metal Nemero integrated pollution index

The soil heavy metal Nemero combined pollution index (PN) showed that the PN ranged from 0.1 to 1.3, with a mean value of 0.3, indicating that the PN was relatively low and the overall environment was relatively safe. There was one heavy metal PN in the soil samples outside the light pollution level, caused by the high content of element As, accounting for 0.92% of the total number of samples, and the rest were in the safe level. In addition, the survey found that the exceeded sample points were distributed in a forested area, which is an artificial forestation area, and it is presumed that the exceeded As may be closely related to the use of pesticides.

4.4 Potential Ecological Risk Index for Soil Heavy Metals

The evaluation of the soil heavy metal hazard index (Ei) shows that, as shown in Table 5, the single factor potential ecological risk index of all soil samples in the region is less than 40, except for Hg, which is a slight ecological risk; the potential ecological risk index of As ranges from 3.54 to 52.16, which is mainly a slight ecological risk, accounting for 99.06% of the total number of samples; the potential ecological risk index of Cd ranges from 12.85 to The potential ecological risk index of Cd ranged from 12.85 to 64.28, with minor to moderate ecological risks, mainly minor ecological risks, accounting for 77.55% of the total number of samples, and moderate ecological risks accounting for 22.43% of the total number of samples. Therefore, the main potential ecological risk elements of soil heavy metals in the study area are Cd and Hg.

The mean value of the total potential ecological index (RI) of soil heavy metals was 142.71, with slight to very strong ecological risks, among which the proportion of slight and moderate was 74.76% and 19.64% respectively, and there were a small number of samples with strong potential ecological risks, accounting for 4.67% of the total number of samples, and only one sample showed a very strong ecological risk. The survey found that these samples were mainly distributed in the central and western parts of the study area, where there were a large number of residential communities, main traffic routes, parks and some production and processing enterprises, which were affected by human activities and production activities for a long time, resulting in high ecological risk of the surrounding soil elements such as heavy metals Cd and Hg (Figure 3). There are extreme values of Hg; the E_i and *RI* values of Hg have a strong consistency in spatial distribution and contribute the most to the total potential ecological risk.

Table 5: Statistics of potential ecological risk index of heavy metals in surface soil of the study area

Single potential ecological risk index	chemical element	*Ei* Scope	*Ei* Average value	Percentage of samples with different risk levels/%(n=340)				
				Minor	Moderate	Stronger	Strong	Extremely strong
Ei	As	3.54~52.16	9.75	99.06	0.94	0	0	0
	Cd	12.85~64.28	32.72	77.55	22.45	0	0	0
	Cr	1.43~2.85	1.91	100	0	0	0	0
	Cu	2.63~14.58	5.36	100	0	0	0	0
	Hg	9.13~675.78	81.33	42.05	29.92	10.27	14.96	2.80
	Ni	3.22~8.58	5.01	100	0	0	0	0
	Pb	3.29~11.38	5.56	100	0	0	0	0
	Zn	0.67~3.26	1.12	100	0	0	0	0
Total potential ecological risk index		RI Scope	RI Average value	Percentage of samples with different risk levels/%(n=340)				—
				Minor	Moderate	Strong	Very strong	
RI		41.42~750.68	142.71	74.76	19.64	4.67	0.93	—

Note: "-" means not mentioned.

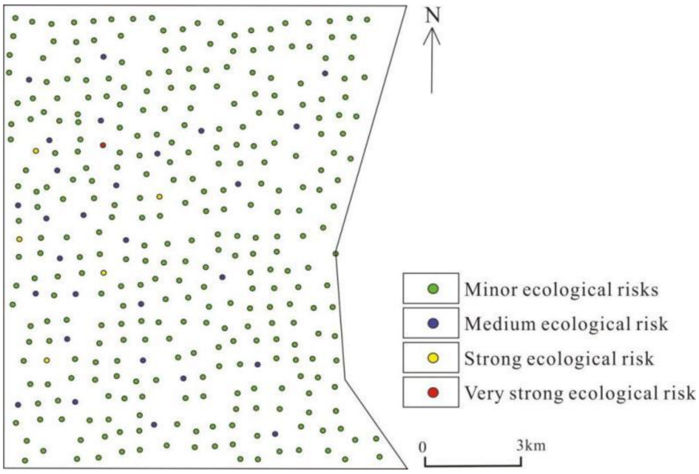

Figure 3: Distribution map of RI of heavy metals in soil of sampling points in study area

4.5 Enrichment factors

Pearson correlation coefficient matrix analysis was performed using SPSS 19 to analyze the correlation between the eight heavy metal elements of soil and the candidate reference elements. Table 6 shows that Mn, Sc, Ti and Fe in soil are positively correlated with the content of As, Cd, Cr, Cu, Ni, Pb and Zn, and the correlation degree is Mn>Fe>Sc>Ti, but Mn has the best correlation, indicating that human activities have less influence on the content of Mn originating from the earth's crust, so it is relatively reasonable to choose Mn as the reference element for soil heavy metal enrichment factor evaluation in this study .

Table 6: Correlation coefficient matrix between eight heavy metals in soil and candidate reference elements

element	Relationships	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Mn	Relevance	0.567**	0.393**	0.667**	0.523**	-0.082	0.727**	0.243*	0.322**
	Significance	0	0	0	0	0.34	0	0.017	0
Sc	Relevance	0.255*	0.367**	0.834**	0.555**	-0.013	0.899**	0.223*	0.277**
	Significance	0.02	0	0	0	0.948	0	0.038	0.004
Ti	Relevance	0.223*	0.234**	0.881**	0.445**	-0.032	0.832**	0.145	0.304**
	Significance	0.023	0.01	0	0	0.831	0	0.154	0.001
Fe	Relevance	0.323**	0.378**	0.843**	0.531**	-0.032	0.846**	0.241*	0.321**
	Significance	0.001	0	0	0	0.742	0	0.012	0.001

Note: ** indicates highly significant correlation ($p \le 0.01$), * indicates significant correlation ($p \le 0.05$), Fe was replaced by Fe_2O_3.

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Soil heavy metal enrichment factor (EF) evaluation results, see Table 7, the average value is generally in the no to weak pollution level, from weak to strong order As < Cr < Ni < Cu < Cd < Zn < Pb < Hg (Figure 4), all soils have no highly polluted and extremely polluted sample points; study area soil samples Cr and Ni enrichment factor are less than 2, all are no to weak pollution state; soil Hg pollution Soil Hg pollution phenomenon is more prominent, the degree of pollution is relatively heavy compared with other heavy metals, pollution samples, soil Hg was significantly polluted in 7 sample points, accounting for 6.54% of the total number of samples; there is one sample soil As enrichment factor was significantly polluted, accounting for 0.93% of the total number of samples; soil Cd, Cu, Hg, Pb and Zn enrichment factor was moderately polluted in 2, 1, 18, 1 and 2 samples, respectively. The mean values of enrichment factors of soil Cr and Ni did not vary much, indicating that the spatial distribution of heavy metals Cr and Ni was mainly influenced by geological background factors, and human activities had less influence on them; the mean values of enrichment factors of soil Hg, Pb, Zn, Cd, Cu and As were relatively large. The mean values of enrichment factors of soil Hg, Pb, Zn, Cd, Cu and As are relatively large, indicating that the enrichment of these heavy metals in soil mainly comes from external unnatural conditions.

Table 7: Statistics of heavy metal enrichment factors in surface soil of study area

element	EF Scope	The proportion of samples with different pollution levels of elements /%(n=340)				
		No-weak contamination	Medium pollution	Significant contamination	Highly contaminated	Extremely polluted
As	0.41~3.24	99.08	0	0.92	0	0
Cd	0.53~2.26	98.14	1.86	0	0	0
Cr	0.51~1.09	100	0	0	0	0
Cu	0.61~2.59	99.07	0.93	0	0	0
Hg	0.25~15.63	76.64	16.82	6.54	0	0
Ni	0.49~1.23	100	0	0	0	0
Pb	0.69~2.01	99.07	0.93	0	0	0
Zn	0.68~2.57	98.15	1.85	0	0	0

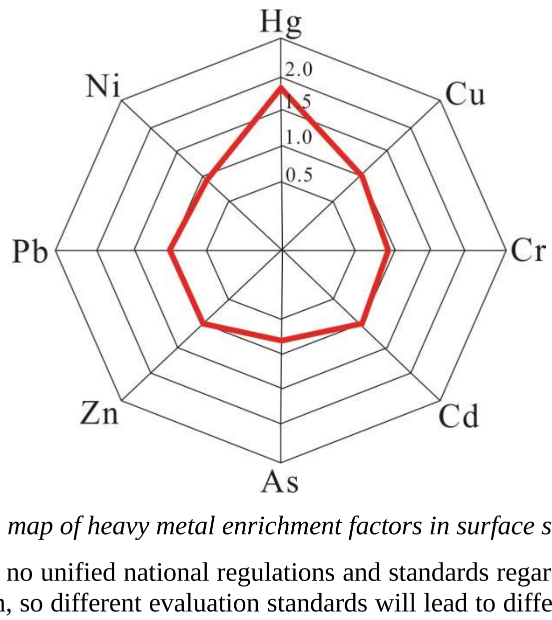

Figure 4: EF mean map of heavy metal enrichment factors in surface soil of the study area

In summary, there are no unified national regulations and standards regarding the risk evaluation of soil heavy metal pollution, so different evaluation standards will lead to different conclusions about the degree of pollution, and since the background value of soil in Hebei Province [17] is lower than the background value of soil elements in China [3] and the screening value of agricultural land, the background value of soil in Hebei Province is used to evaluate the degree of heavy metal pollution, and the results are relatively the most serious. The comprehensive pollution level in the study area is light, and the overall level is in a safe and non-polluting level, and the environment is relatively safe. The total potential risk ecological index (RI) of soil heavy metals in the area is about one-fourth of the medium ecological risk, and the soil heavy metal ground accumulation index (Igeo) shows that the soil Hg pollution is relatively serious, and more than one-third of the samples are at the pollution level. Soil heavy metal enrichment factor (EF) shows that there are sporadic samples with significant contamination of soil Hg and Cd enrichment factors, indicating that long-term human activities and production activities have constituted a certain degree of accumulation of heavy metals in the soil environment of some surrounding soils. According to the screening value standard for agricultural land, the content of eight heavy metal elements in this study area is generally low and meets the standard requirements, and there is still much room for heavy metal environmental capacity.

5. Conclusion

(1) The soils in the study area are alkaline - strongly alkaline, and the elements As and Hg are highly variable elements, among which the coefficient of variation of Hg is 220.59%, indicating that the obvious enrichment of local soils is caused by the influence of human activities. The soil heavy metal content in the zone was most significantly correlated with soil Mn. Only one sample showed mild contamination, mainly caused by its high As content, which exceeded the risk screening value for soil contamination in agricultural land.

(2) The evaluation of soil heavy metal accumulation index (I_{geo}) in the study area showed that As, Cd, Cr, Cu, Ni, Pb and Zn elements were generally non-polluting, and a few lightly polluted samples existed, while soil Hg pollution was relatively serious, with 36.44% of the samples in the pollution level, mainly lightly polluted, and no heavy to very heavy pollution samples; one sample each of As and Zn are in a medium pollution state, and there are no samples of heavy pollution or above. The average value of enrichment factor (EF) of each soil in the area is less than 2, and the average value of enrichment factor from weak to strong is As<Cr<Ni<Cu<Cd<Zn<Pb<Hg, and the overall level of no to weak pollution, but 6.54% of soil Hg and 0.92% of soil Cd are significantly polluted.

(3) Soils in the area are mainly of minor and moderate potential ecological risk, accounting for 74.76% and 19.64%, respectively; there are only scattered soil samples of strong potential ecological risk and very strong potential ecological risk, accounting for 4.67% and 0.93% of the total number of samples, which are mainly distributed in the central and western parts of the study area, where there are a large number of These sample sites are mainly located in the central and western parts of the study area, where there are a large number of residential communities, traffic arteries, parks and some production and processing enterprises, and long-term human activities and production activities lead to high ecological risk of heavy metals such as Hg and Cd in the surrounding soil.

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