Ecological Risk Assessment of Heavy Metals in Surface Soil of Qinghai Lake Area Based on Occurrence Forms

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Abstract

In this paper, the content and speciation of Cd, Cr, Pb, As, Cu, Zn and Ni in 87 groups of soil samples collected by grid method were determined by Inductively Coupled Plasma-Atomic Emission Spectrometry, to explore the speciation characteristics and ecological risk status of heavy metals in surface soil around Qinghai Lake. The results show that: Cd and Pb, compared with Cr, As, Cu, Zn and Ni, in the surface soil around Qinghai Lake are the most seriously polluted, Heavy metal speciation analysis showed that the proportion of weak acid soluble components of Cd was relatively high, with strong mobility and high environmental risk. The reducible components of Zn and Pb account for a relatively high proportion, while the oxidizable components of Cu, Cd and Pb account for a relatively high proportion. The high percentage of residual Cr, Ni and As indicates that they are relatively stable. The extractable content of Cd, Pb and Zn is relatively high, and their activities are strong, which have a great impact on the food chain. The results of Inductively Coupled Plasma-Atomic Emission Spectrometry and the ratio of secondary phase and primary phase showed that Cd and Pb had more serious ecological risk than other heavy metals. According to the results of soil speciation and ecological risk assessment of heavy metals around Chinese and foreign lakes, although the speciation characteristics of heavy metals are different, the pollution of Cd is relatively large. To sum up, heavy metal pollution in soil around Qinghai Lake area has occurred, and there is a serious ecological risk, so it is urgent to take corresponding monitoring and formulate treatment plan.

Synopsis:

This article is mainly through the speciation and risk analysis of heavy metals in surface soil around Qinghai Lake area, to provide regulatory reference for this area.

0 Abstract

The interaction between soil, organisms and surrounding environment continuously provides resources for human beings and ecology, is an important part of human environment, and is the basis of natural ecosystem and agricultural crop production [1–3]. Heavy metals are the most important persistent toxic pollutants in soil, and their effects are difficult to prevent and irreversible [4]. With the continuous development of economy, the expanding scope of people's activities and the continuous updating of technologies, pollutants enter the soil, resulting in the continuous accumulation of heavy metals in the soil, which in turn poses a threat to human beings and the ecological environment [5–6]. Heavy metals' forms transform each other through adsorption, migration and transformation in the soil, resulting in different environmental effects, and their migration and toxicity will also vary with different forms [7].

According to the Bulletin of National Soil Pollution Survey published in 2014, the total soil exceeding standard rate reached 16.1%, among which 7 heavy metal pollutants such As Cd, Ni, As, Cu, Pb, Cr and Zn exceeded the standard point rate by 7.0%, 4.8%, 2.7%, 2.1%, 1.5%, 1.1% and 0.9%, respectively. Since 2000, with the rapid economic development, soil heavy metal pollution in China has been increasingly intensified. As for the speciation of soil heavy metals, studies have shifted from mining areas [8–9], industrial areas [10–11], and along traffic roads [12] to sewage irrigation areas [13–14], orchards [15–16], wetlands [17–18] and agricultural land [19–20]. At present, the research on heavy metals in lakes at home and abroad mainly focuses on the coastal areas, lakes around urban areas, urban important landscape water and sediments, etc., and also includes the study on the characteristics and forms of heavy metals in lakes and their sediments, ecological assessment, risk assessment, etc. [21–25].

Qinghai Lake is the largest inland saltwater lake in China, with spectacular and beautiful scenery and vast territory. It is an important water body to maintain the ecological security of the northern part of the Qinghai-Tibet Plateau [26]. Its shore is an important animal husbandry area in the northeastern part of the Qinghai-Tibet Plateau, with vast natural

pastures, large fertile fields, rich pastures and mineral resources, which is a national key ecological protection zone. Soil nutrients and soil water resources are the focus of many geographers [27–28]. There have been some researches on the heavy metals in the soil of Qinghai Lake area, and some important results have been obtained [29–30]. For example, Wang et al. [31] analyzed the heavy metals in the northeastern surface soil of Qinghai Lake Basin, and found that copper and zinc were deficient and lead was enriched compared with the continental crust, so as to study the geochemical model, determine the possible sources and discuss the meaning of chemical weathering. Chang Huajin et al. [32] evaluated the pollution degree and source analysis of 9 heavy metals in the sediments of the lower reaches of the Shaliu River, and evaluated their risk degree. Lin et al. [33] analyzed the influence of salinity, pH and other factors on the content of heavy metal cadmium in sediments and topsoil in Qinghai Lake area, and found that the enrichment degree of cadmium in lake sediments was significantly higher than that in the surface soil around the lake. But these studies mainly focus on the lake water body, and the evaluation of the river sediment of heavy metal content, and limited to a small area of Qinghai Lake or a particular landscape type, to be carried out for the entire system research of soil heavy metal pollution around Qinghai Lake region, there is almost no study of heavy metals in the region and based on the ecological risk assessment in the form of heavy metals. Recently, with the impact of climate change, tourism development and surrounding enterprises [34], the environment in the surrounding areas of Qinghai Lake has been damaged, and grassland degradation, desertification and other ecological problems have occurred in the land [35–36]. These uncertain factors will lead to the different distribution and proportion of heavy metals in the soil, and also have a certain impact on their migration. Therefore, the analysis of soil heavy metal speciation is an indispensable part in the study and evaluation of environmental pollution. In view of this, this paper takes the whole area around Qinghai Lake as the research object, and discusses the pollution distribution characteristics, occurrence forms and ecological risks of heavy metals in the surface soil of this region, so as to provide theoretical support and practical data reference for the protection of the ecological environment and human health in Qinghai Lake region.

1 Methods And Materials

1.1 Overview of the study area

The study area is located in the northeast of Qinghai-tibet plateau around Qinghai Lake region, namely G109 highway, G315 road, the east and the west road within the surrounding area, surrounding monsoon region in the eastern part of our country, arid zone of northwest and southwest GaoHan District intersection zone, belongs to the typical plateau semi-arid, cold climate [37], where an average elevation of 3000 m above, and terrain tilt from west to east. It is high in the northwest and low in the southeast, and has two landforms: Qinghai-Tibet Plateau and Loess Plateau. It is snowy in winter and rainy in summer and autumn, with low temperature, big regional differences, big temperature difference between day and night, insufficient precipitation and concentrated period, distinct dry and wet season, intense sunshine and long time, solar radiation intensity increasing from southeast to northwest [38], annual average temperature ranging from -4.6°C to 4.0°C , annual average precipitation ranging from 291.0 to 579.0 mm, mostly concentrated in June to September [39]. Due to landform, climate, land use type and other factors, different land types in Qinghai Lake area mainly include mountain meadow soil, mountain shrub meadow soil, chernozem soil, chestnut soil, aeolian sand soil, etc. [40].

1.2 Methods for sample collection and determination

Before sampling, ArcGIS software was used to divide the remote sensing images of the area around Qinghai Lake into grids. A sampling point was laid out in each grid with a sampling density of 5 km. During the sampling in late May 2019, the sampling points were reasonably laid out by adjusting the location due to the actual factors such as terrain, buildings and Bridges, etc., through field survey. The distribution of sampling points is shown in Fig. 1. A total of 87 groups of mixed surface soil samples (0 ~ 20cm) were collected by five-point method, including 79 grassland sites, 4

farmland sites (No. 54, 59, 60 and 82) and 4 sandy land sites (No. 5, 6, 29 and 30). The elevations of sampling points ranged from 3140 m to 3237 m.

The soil samples were pre-treated and the microwave digestion process was carried out in accordance with the "Microwave Digestion Method for Total Metal Elements in Soil and Sediments" (HJ832-2017) issued by the Ministry of Environmental Protection. After digestion, the content and speciation of heavy metals in the soil were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES) after the supernatant was mixed to 25 mL at a constant volume and stood for 60 minutes.

1.3 Extraction and analysis of heavy metal speciation in samples

At present, Tessier method and BCR method are often used to classify heavy metal speciation in soil and sediments, including their improved methods. Among them, BCR three-step continuous extraction method has more practical significance and has been applied in the study of heavy metal speciation in soil by many scholars [41–42]. In this study, the improved BCR continuous extraction method was used to extract the heavy metal speciation from the surface soil samples around Qinghai Lake. See the references for the experimental process [43–44]. Finally, the measured values of various forms of heavy metal elements in the soil were calculated, and the recovery rate was 100% $\pm$ 20%, indicating that the results of the speciation extraction in this study were reliable.

1.4 Quality control and data processing

This experiment in order to guarantee the reliability and accuracy of the experimental data, determine the time resolution of 16 samples to add two blank sample, morphological analysis process each step 2 blank samples were set up, take 10% of the sample do parallel sample analysis at the same time, the quality of the results of the analysis precision of test, the results measured the relative deviation meets the requirement of quality control [45–46]. Microsoft Excel 2016 and SPSS 20.0 software were used to make descriptive statistics and analysis of the data of soil heavy metal content, and the analysis results were plotted. The distribution map of soil sampling points was made by using ArcGIS 10.5.

2 Results And Dissscussion

2.1 Analysis of heavy metal content and physicochemical indexes in soil

Descriptive statistical analysis of the heavy metal content of surface soil around Qinghai Lake and the physical and chemical properties of the soil are shown in the following table (Table 1). The results show that The average contents of heavy metals Cd, Cr, Pb, As, Cu, Zn and Ni in the soil were 0.62 mg/kg, 41.35 mg/kg, 21.86 mg/kg, 11.73 mg/kg, 19.33 mg/kg, 63.51 mg/kg and 21.18 mg/kg (Table 1). On the whole, only the mean contents of heavy metals Cd, Pb and As in the soil of the study area exceed the background value of heavy metals in Qinghai Lake soil [47]. From the perspective of single heavy metal elements, the content of Cd in the soil with the number of sample points accounting for about 84% exceeded the background value, accounting for the largest proportion. Among them, the content of 7 sample points even exceeded 5 mg/kg, which was about 40 times of the background value of the soil, seriously exceeding the background value. When the number of samples accounted for 59.8%, the multiple of Pb content in the soil exceeded the background value by less than 1 times. As, Cu, Zn, Cr and Ni accounted for 40, 35, 25, 12 and 8 samples that exceeded the background value, and the multiples beyond the background value were generally less than 0.5 times. In addition, the soil pH value of the sample sites in the study area ranged from 7.08 to 10.14, with an average value of 8.07. According to the soil pH classification standard, the surface soil in the study area was alkaline on the whole, and the pH value of all the soil sample sites was alkaline. However, the variation coefficient of the seven heavy

metals in the soil was only larger, Cd, which was 2.29 (Table 1), indicating that Cd in the soil in the study area was more affected by external factors than other elements. In conclusion, the soil in the study area has been polluted by heavy metals, among which Cd and Pb are the most seriously polluted, followed by Cr, As, Cu, Zn and Ni.

Table 1
Descriptive statistics of heavy metals and physicochemical properties of topsoil around Qinghai Lake.

	Cd	Cr	Pb	As	Cu	Zn	Ni	pH	Organic matter	Grain composition(clay ratio)
Minimum	0.05	11.50	7.46	0.96	2.06	17.30	6.23	7.08	1.23	0.00%
Maximum	5.57	60.93	35.09	18.52	74.38	98.62	31.62	10.14	103.05	100.00%
Mean	0.62	41.35	21.86	11.73	19.33	63.51	21.18	8.07	34.60	9.40%
Coefficient of variation (CV)	2.29	0.32	0.30	0.32	0.46	0.31	0.33	0.06	0.67	1.45
Background value of soil in Qinghai Lake [48]	0.14	54.17	20.47	11.66	19.72	64.28	24.96	-	-	-
Note: Unit of heavy metal content in the table: mg/kg										

2.2 Speciation analysis of heavy metals in soil

The speciation of heavy metals in soil varies according to the living environment and changes to different degrees, which is closely related to the toxicity, migration and circulation of heavy metals in nature [5, 48]. In the improved BCR speciation extraction process, the heavy metals can be divided into four kinds of occurrence states: weak acid soluble state, reducible state, oxidizable state and residue state [49].

The mean analysis results of heavy metal occurrence speciation in the surface soil around Qinghai Lake are shown in Fig. 2. In terms of different heavy metals, the morphology of the 7 heavy metal elements are as follows: the weak acid soluble state and residue state of Cd are the most, followed by oxidizable state and reducible state. Cr, Pb, As, Cu, Zn and Ni have the largest proportion of residual states, and the smallest proportion of weak acid soluble states. The morphology of Cr, As, Cu and Ni is the same, and the oxidizable state is larger than the reducible state. The morphology of Pb and Zn is the same, and the oxidizable state is smaller than the reducible state.

In terms of the content ratios of different forms, the order of the proportion of the seven heavy metals in the surface soil around Qinghai Lake was Cd (34.8%) > Pb (9.8%) > Zn (9.4%) > Cu (4.3%) > Ni (2.5%) > Cr (2.3%) > As (2.1%). The order of reducible specific gravity was Zn (32.8%) > Pb (27.8%) > Cd (13.8%) > As (11.3%) > Ni (9.5%) > Cu (7.6%) > Cr (5.3%). The order of oxidation state specific gravity was Cu (36.8%) > Cd (25.3%) > Pb (22.8%) > As (18.5%) > Ni (14.7%) > Cr (14.3%) > Zn (12.2%). The order of residual specific gravity was Cr (78.1%) > Ni (73.3%) > As (68.1%) > Cu (51.3%) > Zn (45.6%) > Pb (39.6%) > Cd (26.1%).

It can be seen that Cr, Pb, As, Cu, Zn and Ni are mainly in the form of residual heavy metals, which are stable and difficult to be released and absorbed by plants, so they have little impact on the food chain [50], while Cd is mainly in the weakly acid soluble state. Weakly acid soluble, reducible and oxidizable heavy metals are all extractable states, and the higher the proportion of extractable states, the stronger the migration and toxicity of heavy metals [51]. The extractable contents of heavy metals Cd, Cr, Pb, As, Cu, Zn and Ni in the topsoil of the study area were Cd (73.9%) > Pb

(60.4%) > Zn (54.4%) > Cu (48.7%) > As (31.9%) > Ni (26.7%) > Cr (21.9%). It can be seen that the extractable contents of Cd, Pb and Zn account for a large proportion, all of which exceed 50%. Therefore, they have strong activity, are easy to be transferred, transformed and absorbed by plants, and have a great impact on the food chain. For example, plants, earthworms and other animals in the soil, cattle and sheep and other animals in the land eat them, thus harming human health. The extractable contents of Cu, As, Ni and Cr accounted for between 20%-50%, which was relatively low. The migration and transformation ability was low, which was in a relatively stable state, and had low bioavailability and toxicity.

2.3 Ecological risk assessment of heavy metals in soil

The following two methods are used to evaluate the ecological risk of heavy metals in soil: risk assessment coding index and comparison value method of secondary phase and primary phase.

(1) The RAC risk assessment coding index proposed by Perin [52] in 1985 can be used to evaluate the bioavailability and availability of metals in solid media [53], which is determined by the ratio of exchangeable (i.e. weak-acid soluble) metals to the total content of a metal. According to the magnitude of the ratio, the risk was divided into five levels [54]: $RAC < 1\%$, no risk, $1\% \leq RAC \leq 10\%$, low risk, $10\% < RAC \leq 30\%$, moderate risk, $30\% < RAC \leq 50\%$, high risk, $RAC > 50\%$, very high risk.

(2) The secondary phase compared to native (RSP) is a kind of value method based on soil and sediment geology to assess the size of the migration of heavy metals in sediment source and release risk method [55–56], to express the degree of heavy metal pollution said secondary phase (except the residue of other form) and heavy metal content in the primary phase (residue) the ratio of $RSP < 1$ for pollution-free, $1 \leq RSP < 2$ is light pollution, $2 \leq RSP < 3$ is moderate pollution, and $RSP \geq 3$ is heavy pollution [57].

The results of the risk assessment coding index RAC and the comparison value of secondary phase to primary phase RSP are shown in Table 2. In terms of RAC, the mean values of the risk assessment coding index for heavy metals in 87 samples were 34.8% (Cd), 2.3% (Cr), 11.4% (Pb), 2.1% (As), 4.3% (Cu), 9.4% (Zn) and 2.5% (Ni), respectively. It can be seen that, except high risk Cd and medium risk Pb, the other five heavy metals all have low ecological risk. According to the RSP method, the mean value of the RSP for the secondary phase and primary phase of each heavy metal in 87 samples in the study area showed that there was moderate pollution of Cd, slight pollution of Pb and Zn, and no pollution of other heavy metals. In conclusion, Cd and Pb are serious heavy metals in the surface soil around Qinghai Lake.

Table 2
Ecological risk assessment of heavy metals in topsoil around Qinghai Lake.

	Cd	Cr	Pb	As	Cu	Zn	Ni
Average RAC/%	34.8	2.3	11.4	2.1	4.3	9.4	2.5
RAC risk level	High risk	Low risk	Moderate risk	Low risk	Low risk	Low risk	Low risk
Average RSP	2.7	0.3	1.5	0.5	0.9	1.2	0.4
RSP risk level	Moderate pollution	No pollution	Light pollution	No pollution	No pollution	Light pollution	No pollution

2.4 Comparison of heavy metal speciation in soils around various domestic and foreign river basins

There have been some studies on the soil heavy metal speciation around lakes or river basins at home and abroad. Combined with the literature found, this paper summarized the study on the soil heavy metal speciation around lakes in China and compared it with the results of this study on the percentage of each heavy metal speciation in the total soil around Qinghai Lake, as shown in Table 3.

Table 3

Comparison of the proportions of four forms of heavy metals in soils around Qinghai Lake and other watersheds.

Heavy metal	Qinghai Lake	Daye Lake Basin [58]	Three Gorges Reservoir [59]	Yangtze River [60]	Yellow River Delta [61]	Turkey Göksu Delta[64]	Sapanca Lake[65]	Sinú River[66]
Cd	a > d > b > c	d > a > c > b	d > a > c > b	a > d > c > b	d > a > c > b	b > c > d > a	d > c > b > a	b > c > d > a
Cr	d > b > c > a	-	d > b > c > a	-	d > b > c > a	b > d > c > a	d > b > c > a	-
Pb	d > c > b > a	d > c > b > a	d > c > b > a	d > c > a > b	d > c > b > a	b > d > c > a	c > d > b > a	b > c > d > a
As	d > b > c > a	-	d > c > b > a	-	-	d > b > c > a	b > c > a > d	-
Cu	d > b > c > a	d > b > c > a	d > c > b > a	d > c > b > a	d > c > b > a	b > c > d > a	d > c > b > a	b > c > d > a
Zn	d > c > b > a	d > b > c > a	d > c > b > a	-	d > c > b > a	a > b > d > c	d > c > b > a	b > c > d > a
Ni	d > b > c > a	-	-	-	d > c > b > a	b > d > c > a	d > b > c > a	b > c > d > a
Note: the weak acid soluble state, oxidizable state, reducible state and residual state in the table are represented by a, b, c and d respectively.								

Compared with the area around Qinghai Lake, the following results were obtained: (1) Compared with the area around Qinghai Lake, the forms of Cd in the soil heavy metals in Daye Lake Basin were mainly dissolved in weak acid and residual state, and the residual state accounted for the largest proportion of Pb, Cu and Zn forms. (2) Compared with that in the Three Gorges Reservoir area and the Qinghai Lake area, the forms of Cd in the soil heavy metals are mainly dissolved in weak acid and residual state, and the proportion of residual state in the forms of Cr, Pb, As, Cu and Zn is the largest. (3) Compared with the area of Qinghai Lake and Wuhan section of Yangtze River, the forms of Cd in soil heavy metals are mainly weak acid soluble and residual state, and the proportion of weak acid soluble state is the largest, while the proportion of residual state of Cr, Pb, As, Cu, Zn and Ni is the largest. (4) Compared with the Qinghai Lake area, the forms of Cd in the Yangtze River area are mainly dissolved in weak acid and residual state, and the proportion of residual state in Pb and Cu forms is the largest. (5) Compared with the Qinghai Lake area, the proportions of Cd, Cu and Zn in soil heavy metals in the Göksu Delta area were relatively small, contrary to the situation in the Qinghai Lake area, while the proportions of Cr, Pb, As and Ni in soil heavy metals were relatively large. (6) Compared with the Sapanca Lake area, the proportion of weak acid soluble state in the form of soil heavy metals Cd in the Sapanca Lake area is relatively small, contrary to the situation in the Qinghai Lake area, while the proportion of oxidizable state in the form of As is relatively large, and the proportion of residual state in the form of Cr, Pb, Cu and Zn is the largest. (7) Compared with the Qinghai Lake area, the proportion of weak acid dissolved state of Cd in the Sinu

River area is relatively small, contrary to the situation in the Qinghai Lake area, and the proportion of residue state of Pb, Cu, Zn and Ni in the soil is relatively small, contrary to the situation in the Qinghai Lake area.

Based on the results in Table 3, it is further concluded that: (1) Compared with the soil heavy metals in the surrounding areas of lakes in China, the forms of Cd are mainly dissolved in weak acid and residual state, while the forms of Cr, Pb, As, Cu, Zn and Ni are mostly residual state. (2) Compared with the concentrations of heavy metals in soils around lakes in foreign countries, the concentrations of heavy metals Cd in foreign countries are opposite to those in China. For Cr, Pb, As, Cu, Zn and Ni in foreign countries, the proportions of oxidizable and reducible states are larger than those in China, and the proportions of residual states are smaller than those in China.

In addition, the ecological risk assessment based on the form of heavy metals in soil around lakes at home and abroad was compared, and the results were detailed in Table 4. The data in the table show that: (1) Compared with Qinghai Lake area, the RAC index shows that the pollution of Cd is more serious, while the pollution of Pb, Cu and Zn is less. (2) Compared with Qinghai Lake area, Rac index showed that Cd was more serious than Cr, Pb, As, Cu and Zn in the Three Gorges Reservoir area. (3) RSP index showed that only As was unpolluted in Zhanjiang Bay and Qinghai Lake, and Cd was the most polluted heavy metal in both regions. (4) Compared with Qinghai Lake area, Rac index and RSP index showed that Cd was the most polluted heavy metal in Jiulong River basin, while Cr, As and Ni were less polluted in the two regions. (5) Compared with Qinghai Lake, the RAC index showed that the pollution of Cr, Cu, Zn and Ni in Sapanca Lake area was less than that in Qinghai Lake area. (6) Compared with Qinghai Lake area, the RAC index shows that the pollution of Cu, Zn and Ni is less, while the pollution of Cd is more serious in the Sinu River area.

Based on the further analysis in Table 4 and Table 5, it can be concluded that the pollution of Cd in the soil heavy metals around lakes in China is the most serious compared with other heavy metals, and the risk level is basically high, while the pollution risk in foreign regions is relatively low.

Table 4
Comparison of heavy metals in soil around Qinghai Lake area and other drainage basins by RAC.

Area		RAC /%						
		Cd	Cr	Pb	As	Cu	Zn	Ni
Qinghai Lake	Average	34.8	2.3	11.4	2.1	4.3	9.4	2.5
	Risk level	High	Low	Moderate	Low	Low	Low	Low
Daye Lake Basin [58]	Average	24.2	-	5.0	-	9.4	5.8	-
	Risk level	Moderate	-	Low	-	Low	Low	-
Three Gorges Reservoir [59]	Average	32.4	0.9	0.9	2.1	2.9	5.0	-
	Risk level	High	No	No	Low	Low	Low	-
Jiulong River basin [63]	Average	47.2	1.7	22.6	13.1	20.3	28.6	6.9
	Risk level	High	Low	Moderate	Moderate	Moderate	Moderate	Low
Sapanca Lake[65]	Average	17.4	1.7	9.4	19.6	7.1	8.4	5.0
	Risk level	Moderate	Low	Low	Moderate	Low	Low	Low
Sinú River[66]	Average	3.0	-	3.0	-	4.0	5.0	4.0
	Risk level	Low	-	Low	-	Low	Low	Low
Note: the reference value of heavy metals in the table is that the coefficient of variation is more than 1, The potential ecological hazard index $Er > 10$.								

Table 5
Comparison of heavy metals in soil around Qinghai Lake area and other drainage basins by RSP.

Area		RSP						
		Cd	Cr	Pb	As	Cu	Zn	Ni
Qinghai Lake	Average	2.7	0.3	1.5	0.5	0.9	1.2	0.4
	Risk level	Moderate	No	Light	No	No	Light	No
Zhanjiang Bay [62]	Average	9.2	2.5	6.0	0.7	9.9	9.7	8.0
	Risk level	Heavy	Moderate	Heavy	No	Heavy	Heavy	Heavy
Jiulong River basin [63]	Average	5.1	0.3	2.6	0.5	1.7	1.3	0.4
	Risk level	Heavy	No	Moderate	No	Light	Light	No
Note: the reference value of heavy metals in the table is that the coefficient of variation is more than 1, The potential ecological hazard index $Er > 10$.								

Combined with the soil heavy metal speciation distribution and ecological risk assessment in the surrounding areas of lakes at home and abroad, the comprehensive results show that the soil heavy metal pollution in the area around

Qinghai Lake is not the most serious on the whole, and the indexes are not much different from those in other areas as a whole, but the indexes in some areas are relatively serious. In a word, Cd is a heavy metal that is easily affected by external factors. According to RAC and RSP indexes, Cd pollution is relatively large both at home and abroad, and the ecological risks in different regions are different to some extent, and some regions are relatively large, which should be paid attention to.

3 Conclusion

According to the above measurement and analysis of heavy metal content in 87 surface soil samples from the area around Qinghai Lake, the surface soil of the area around Qinghai Lake is polluted to different degrees, among which Cd, Pb and As exceed the background value of heavy metals in the soil of Qinghai Lake, while the others are not. Soil Cd pollution levels in the study area is relatively serious, has strong mobility and high environmental risk, easily influenced by outside factors, mainly in the form of the state of weak acid soluble and Cd, Pb, and can extract the states of the zinc content is higher, activity is stronger, a greater influence on the description of the food chain, and the ecological risk of Cd and Pb is serious. Combined with the research findings of relevant areas at home and abroad, the law is consistent. Therefore, these two heavy metals should be the key elements to be paid attention to in the later treatment of soil heavy metal pollution in this region. It is suggested that relevant measures should be taken to reduce their biological effectiveness.

Declarations

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Figures

Figure 1

Location of surface soil sampling points around Qinghai Lake.

Figure 2

Morphological distribution of surface soil heavy metals in the area around Qinghai Lake.