Evaluation on Soil Spatial Pollution by Cu, Zn, Pb, Cr heavy metal element around the Qinghai Lake Region

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***Abstract*—as an important sign of deterioration of soil environmental health quality, soil heavy metal pollution is closely watched by scholars at home and abroad. Combined the Kriging Interpolation method in the GIS spatial analysis, this paper evaluated the Cu, Zn, Pb, and Cr heavy metal spatial pollution status around the Qinghai Lake region using the methods of single-factor pollution index and the Nemerow compresensive pollution indices. Results showed that surface layer soil around the Qinghai Lake region was slightly polluted by Cu, Zn, Pb and Cr, while Cu pollution mainly occurred in Daotanghe Town and Jiangxigou Countryside in the southern bank of the Qinghai Lake, Quanji Countryside and Haergai Countryside in the northern bank of the Qinghai Lake; Zn, Pb and Cr pollutions have similar spatial traits, which chiefly occurred along Daotanghe-Jiangxigou countryside, the other regions showed no pollution by these elements. Nemerow Pollution Index showed that soil pollution around the Qinghai Lake region were slightly polluted by four heavy metals, which reminds us that we should pay sufficient attention to tourism and densely populated area around this region.**

***Keywords*—soil, heavy metal pollutions, spatial distribution, Qinghai Lake region, evaluation**

I. INTRODUCTION

The protection of soils is and should be a principal objective of environmental policy. Soils are a finite, increasingly scarce and non-renewable resource with varying biological, chemical and physical properties [1]. Large quantity of heavy metals in soil will not pollute water and the atmosphere but endanger human's health by entering human body through food chain. Among the heavy metal, copper (Cu) were the targeted hazardous substances for regulation. Cadmium (Cd), in particular, has been recognized as one of the most detrimental elements in Japan, because of the so-called "itai-itai" disease it caused [2]. Therefore, real-time evaluation on soil pollution by heavy metal could provide basis for pollution control. Much work has been done at home and abroad on evaluation of urban pollution by heavy metals [3-6], heavy metals accumulation and contamination in agricultural soils [7-9], but few reports on soil pollution by heavy metals around the alpine lake. Therefore, we studied soil pollution by Cu, Zn, Pb and Cr around the Qinghai Lake region by means of Single-factor Pollution Index, Nemerow Pollution Index and GIS spatial analysis, we hope to supply scientific basis for environment protection and treatment around the Qinghai Lake region.

II. MATERIAL AND METHODS

A. Sketch of studying region

Lake Qinghai (36°32′–37°15′N, 99°36′–100°47′E) located at the northeastern margin of the Qinghai-Tibet plateau in China. Its elevation ranges from 3 200 m to 4 200 m above sea 1evel [10], with a mean altitude of 3,194 m. The local climate is characterized as dry, cold, and windy. Annual average air temperature (1951–2005) is ∼1.2℃. During summer, the lake becomes temperature stratified (hypolimnion < 6℃, epilimnion 12–15℃) and the water mixes and then is covered by ice during October and April [10]. Mean annual precipitation

(1951–2005) is 336.6 mm, but evapotranspiration is three to four times higher than that of precipitation [12]. Main vegetation types include alpine meadow, warm steppe, alpine sparse vegetation, shrubs, and swamps et al [13].

B. Soil sampling and analysis

We randomly selected and positioned by GPS sampling sites around the Qinghai Lake region according to different plant communities in August, 2010. We randomly collected five soil samples (0-10 cm) in a 5m×5m plot using an earth boring auger with diameter of 5cm, all the samples were mixed into one and placed in a soil sack, we collected 66 samples altogether. Then they were air dried and impurities removed, and then put them into oven and dried to constant weight preserved the samples under seal after grinding through 200 mesh sieves. 0.60~0.80 g soil sample was digested by the $HClO_4$-HNO_3-HF mixture. After the digesting process completed, the sample was cooled and fixed to 50 ml volumetric flask used to measure the heavy metals. Cu, Zn, Pb, Cr concentration was measured by atomic absorption spectrophotometry. Results were expressed in mg ·kg^{-1}dry weight.

C. Data analyses

Aaccording to reference standard of soil heavy metals content according to the soil environmental background values in the Qinghai Lake basin[14] (Table Ⅰ).

TABLE Ⅰ REFERENCE STANDARD OF SOIL HEAVY METALS CONTENT Unit : mg/kg

Factors	*Cu*	*Zn*	*Pb*	*Cr*
Values	19.72	64.28	20.47	54.17

This paper evaluated the heavy metal pollution status using the methods of single-factor pollution index and the Nemerow combined pollution index. Two methods are briefly introduced as follows:

(1) Single-factor pollution index[15]

$$P_i = \frac{C_i}{S_i} \qquad (1)$$

Where, P_i represents the environmental quality index of soil heavy metal i; C_i represents the measured values of each heavy metal i, mg ·kg^{-1}; S_i represents the evaluating standard values of each heavy metal in the soil environmental quality standards, mg ·kg^{-1}. If the P_i value is less than 1, the value indicates that soil is not polluted, on the contrary, the $P_i>1$, indicating that soil is yet polluted. Moreover, P_i value is bigger, showing that soil is more serious pollution.

TABLE Ⅱ THE GRADES OF THE SINGLE-FACTOR POLLUTION INDEX

Grade	*Pi*	*Polluting levels*
Ⅰ	Pi≤1	Clean
Ⅱ	1<Pi≤2	Slight pollution
Ⅲ	2<Pi≤3	Moderate pollution
Ⅳ	Pi>3	Heavy pollution

(2) Nemem combined pollution indices

$$P_N = \sqrt{\frac{P_{imean}^{2} + P_{imax}^{2}}{2}} \qquad (2)$$

Where, P_N represents the Nemem combined evaluating indices; P_{imean} represents the mean of single-factor pollution index of each heavy metal; P_{imax} represents the max heavy metal single-factor pollution index.

Table Ⅲ THE GRADES OF NEMEROW COMPREHENSIVE POLLUTION INDEX[16]

Levels	*Nemerow comprehensive pollution index*	*Polluting levels*
Ⅰ	PN≤0.7	Clean(safe)
Ⅱ	0.7<PN≤1.0	Still clean(warning line)
Ⅲ	1.0<PN≤2.0	Slight pollution
Ⅳ	2.0<PN≤3.0	Moderate pollution
Ⅴ	PN>3.0	Heavy pollution

As Single-factor Pollution Index and Nemerow Pollution Index could just reflect pollution degrades of sampling sites, Kriging interpolation method is used to demonstrate spatial distribution traits of heavy metal pollution around this region.

III. RESULTS AND ANALYSES

Results on evaluation of surface soil pollution around Qinghai Lake region by four kinds of heavy metal show that （Fig. 1-2）soil in Daotanghe township, Jiangxigou township along southern lakeside and Quanji township, Haergai township along northern lakeside is slightly polluted by Cu, the other regions are unpolluted(Fig.1A). Spatial distribution traits of Zn, Pb and Cr are similar to each other along eastern-southern lakesides as slightly pollution, the other regions show no pollution, and some parts of the region show a little variation (Fig.1B, Fig.2).

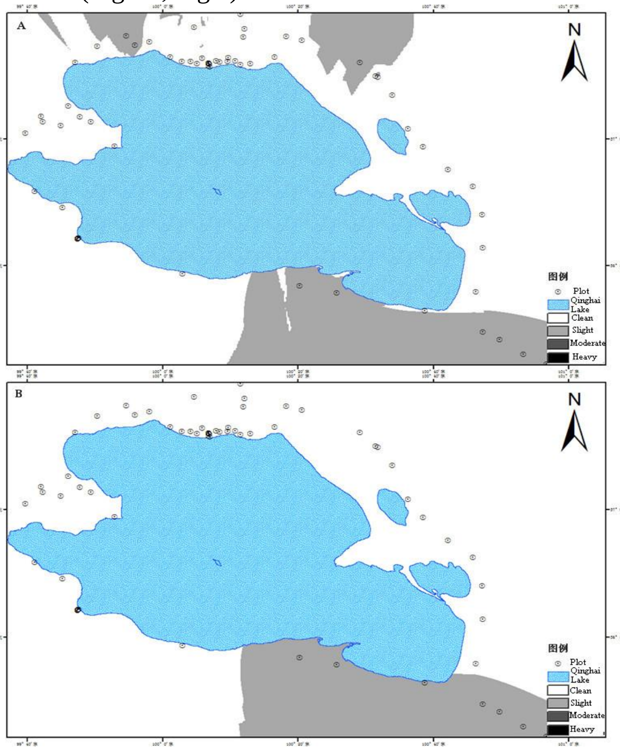

Fig. 1 the Single pollution assessment of Cu (A) and Zn (B) element around the Qinghai Lake region

The Nemerow Pollution Indices (Fig. 3)of a series of townships of Daotanghe, Jiangxigou, Tanggemu, Heimahe in southern lakeside and Jiermen, Quanji, Haergai and Ganzihe in northern lakeside show low degree pollution, the other regions show unpolluted. Because Nemerow Pollution Index considered the most polluted factors in particular, the result might stay higher, which reflects serious pollution degree.

The pollution around this region could be derived from three sources from above analyses: firstly, with fast development of tourism around Qinghai Lake and increase of population, restaurant sanitary sewage may pollute the environment by enriching in soil or lake water instead of centralized processing; secondly, Chemical fertilizers, pesticides and herbicides may be major pollutants due to some farms surrounding Qinghai Lake area; thirdly, there are not any garbage disposal facilities such as refuse landfill around this region, some pollutants containing heavy metal pollute soil through atmospheric diffusion, precipitation or leaching.

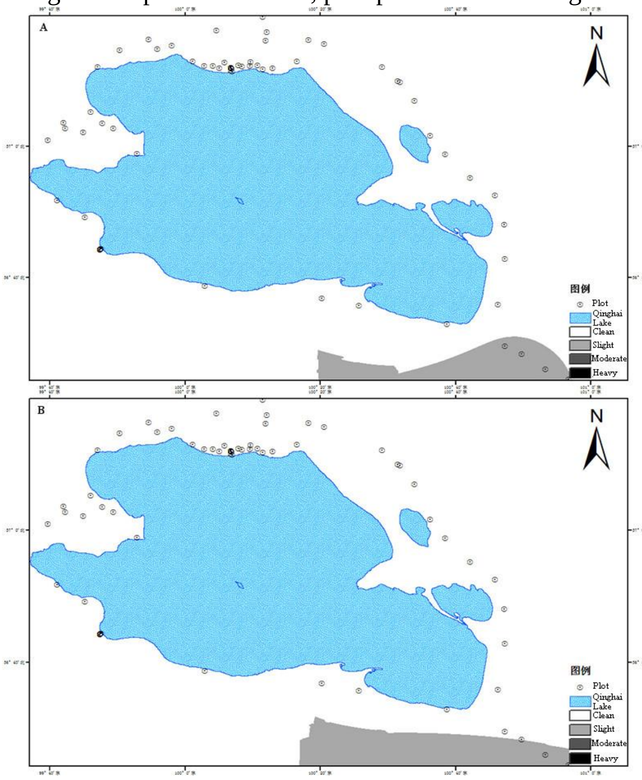

Fig. 2 the single pollution assessment of Pb (A) and Cr (B) elements around the Qinghai Lake

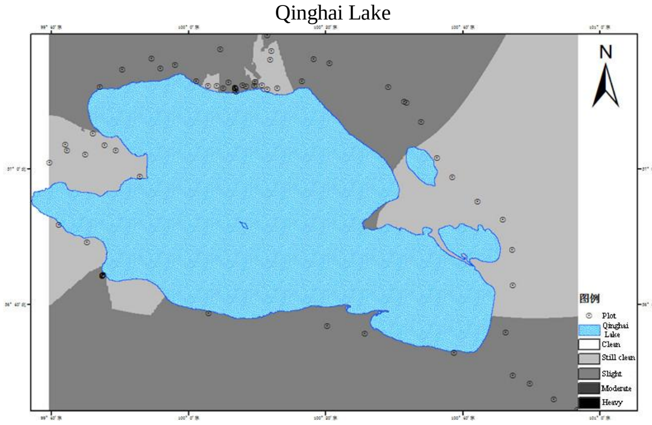

Fig. 3 the Nemerow pollution comprehensive evaluation around the Qinghai Lake region

IV. CONCLUSIONS

Pollution indices of surface soil along Qinghai Lake region show that soil in Daotanghe township, Jiangxigou Township along the southern lakeside and Quanji township, Haergai township along the northern lakeside is slightly polluted by Cu, the other regions are unpolluted. Spatial distribution traits of Zn, Pb and Cr are similar to each other along eastern-southern lakesides as slightly pollution; the other regions show no pollution. The Nemerow Pollution Indices of a series of townships of Daotanghe, Jiangxigou, Tanggemu, Heimahe in southern lakeside and Jiermen, Quanji, Haergai and Ganzihe in northern lakeside show low degree pollution, the other regions show unpolluted. This research results show that heavy metal pollution by tourism surrounding the Qinghai Lake region and in dense-populated areas should be paid sufficient attention.

V. ACKNOWLEDGMENT

This paper is co-sponsored by National Social Science Foundation (10CJY015), Western Light Project of Chinese Academy of Sciences, and Innovation Program of Qinghai Normal University. The authors would like to thanks to them. And thanks to the anonymous reviewers.

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