

The Study of the Correlation between Magnetic Susceptibility and Contaminated Topsoil with Heavy Metals around the Qinghai Lake Area

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Abstract—The magnetic susceptibility and the concentrations of Cu, Zn, Pb, Cr and Mn in topsoil samples from Qinghai Lake Area were measured to study their spatial distribution and their correlation in this study. The results show that: (1) Spatial distribution of topsoil magnetic susceptibility has a certain regularity in study area, showing south shore is high, north shore is low; (2) Cu, Zn, Pb and Cr are significantly positively correlated with magnetic susceptibility, while Mn are significantly negatively correlated with it. The spatial distribution of magnetic susceptibility is identical with the concentrations of Cu, Zn, Pb and Cr. However, the spatial variation of magnetic susceptibility is different from the concentrations of Mn. (3) Soil magnetic susceptibility can be used as an effective monitoring means for heavy metal pollution in Qinghai Lake Area soil.

Keywords—Qinghai lake; magnetic susceptibility; heavy metal; spatial distribution

I. INTRODUCTION

Magnetic susceptibility is a major factor for environmental magnetic study [1]. The integrated study of magnetic susceptibility between heavy metal and the study of environmental change based on correlation between magnetic characteristic and heavy metal ion are the current trend of environmental magnetic study [2-5].

Former [6-12] researches adopt the magnetic susceptibility as an index for human intervenes to environmental contamination to study the correlation between the magnetic susceptibility and the heavy metal ion in the soil. In recent years, scholars have done lots research among the spatial distribution variation, the correlation between As and the magnetic characteristics of the sediment from the aquiclude which is rich of As, the magnetic characteristics of the top soil on different parent rock, the magnetic susceptibility of the soil contaminated by heavy metal mining, the magnetic susceptibility study on the sediment from the river valley in the mining zone of Pb and Zn [13-20], however the study of magnetic susceptibility as soil contamination index is rarely reported.

Located in the conjunction area among high and cold zone of Qingnan Plateau, the Northwest Arid Zone and the East Monsoon Region, Qinghai Lake is the largest inland

salty lake of China, and the major water body to maintain ecological security of northeast of Qinghai-Tibetan Plateau either. It also plays important role as a barrier to stop desertification from west to east. The ecological situation would not only impact on the eco-system development within its border but also exert an influence on the eco-environment and sustainable development of the head zone for rivers (SNNR area), the Qaidam Basin, the east region of Mt. Qilian and the Huangshui Valley east of Qinghai Province.

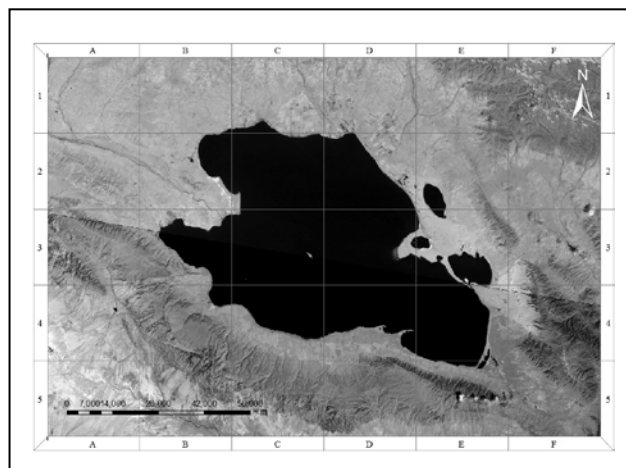


Figure 1. Qinghai Lake map

II. GENERAL SITUATION ON THE STUDY ZONE AND METHODOLOGY

Qinghai Lake is also known as Huhnoor, which is the Mongolian language for the meaning of *Cyan Sea*. Qinghai Lake is the largest lake of both salty and fresh lakes in China. Surrounding by high mountains, it located in the Qinghai Lake basin northeast of the province, which Datong hill to the north, Riyue Mountain to the east as the boundary between agri-zone to animal husbandry region, plateau hills region to the west, Qinghai Nanshan hill to the south, the Yeniu Hill to the southeast (Fig. 1). The annual average temperature is between 1.1-0.3°C, and annual precipitation is around 379.1mm compare with the annual evaporation is

up to 1502mm. The annual duration of sunshine is 700 hrs above the average time among the same latitude and is around 3000 hrs. the max water temperature is 22.3°C, which the average is 16°C; the frozen point is below 0°C due to rich of mineral salt, the average frozen duration is 108 to 116 days a year; the lake covers about 4500km² at the average altitude of 3200m[21].

This sampling of this study is alongside the lake road which parallel to Lake Shoreline by using hand drill to take samples of the top soil; the sampling adopted the principle of avoid human intervene; in order to reduce the random of the single sample, it takes 5 samples in each sample site of 10m², and then mix the samples of the same site thoroughly, the sample soil is the 0~5cm top soil; the sample also has the GPS coordination from the hand hold GPS equipment with vegetarian coverage. 66 top samples has been collected (Fig. 2).

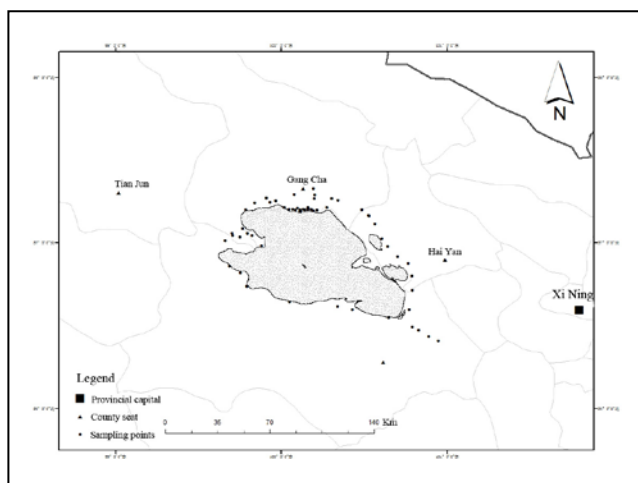


Figure 2. Location and Sampling Distribution map of Qinghai Lake

A. The Measurement of Heavy Metal of Soil Sample

Stones and the major relics of biomass has been removed from sample in the lab, the sample stamp crushed in agate mortar, dried in room temperature and screened by 2mm griddle, measured by electronic scale, boiled with hydrogen nitrate and perchloric acid, measured by atom absorption spectrophotometer; the methodology adopted is joint approach of national standard and Method 3050B of USEPA, results shown are the content of Cu, Zn, Pb, Cr and Mn in the soil sample.

B. The Measurement of Magnetic Susceptibility of Soil Sample

Wrapped the screened soil sample with food-level plastic foil, compacted the wrapped sample within the nonmagnetic plastic box, using electronic scale to ensure the sample mass is 10±0.001g, the British made Bartington MS2 two-band magnetic susceptibility measurement equipment had been used for magnetic measurement at the frequency of 0.47kHz (low) and 4.7kHz (high), all test had been triplicated, all triple results had been recorded for average results at high and low frequency. The unit for the results is 10⁻⁸ m³/kg and magnetic susceptibility was

calculated based on the results.

III. RESULTS

A. The Spatial Distribution of Magnetic Characteristic

This study is a systematic research of magnetic characteristic on the Qinghai Lake and it surrounding area, the magnetic susceptibility of the research area is 9.33 ~ 102.57 (10⁻⁸m³/kg), with a high range of variation and average value of 38.22×10⁻⁸m³/kg. To input the magnetic susceptibility value with coordination of the sample into ArcGIS10.0, the data set has been analyzed by Kriging method, the result is shown as the distribution plot of topsoil magnetic susceptibility of Qinghai Lake (Fig. 3). By reading the figure 3, it shows that the Quanji and Ganzihe townships value, around 15×10⁻⁸m³/kg, is significantly low than the south shore, and the Haiyan County and Gangcha County which located at the north shore has a relatively low value; however, Gonghe County of the north shore is significantly high, of which the value of Qinghai Lake tourism site (Erlangjian) to Jiangxigou township is up to 70×10⁻⁸m³/kg; Tourism development, the grazing activities and the fossil fuel consumption are the major cause for high magnetic susceptibility.

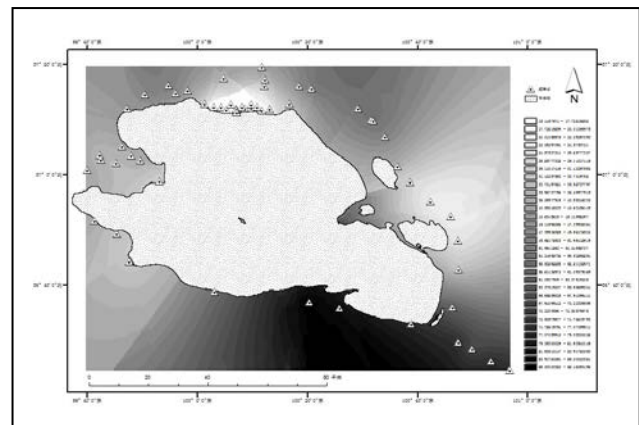


Figure 3. The distribution plot of topsoil magnetic susceptibility of Qinghai Lake

By different grassland types, some of the characteristics of the magnetic susceptibility values were counted (Tab 1). The magnetic susceptibility of different grassland types is quite different. The mean magnetic susceptibility value is in proper order: *Stipa capillata* Linn grassland type>*Achnatherum splendens* grassland type>*Blysmus sinocompressus* Tang et Wang grassland type>*Kobresia humilis* + *Kobresia pygmaea* grass grassland type>Bare land+Arable land type; Soil erosion of Bare land + Arable land type is very serious and the wind deposition efficiency is low, so its mean magnetic susceptibility value is the lowest. Because of the high deposition rate in *Stipa capillata* Linn grassland type and the intensity of the people and livestock activities, its mean magnetic susceptibility value is relatively high. Different grassland types have a certain influence on the magnetic susceptibility. In *Stipa*

capillata Linn grassland type the magnetic susceptibility maximum is $89.7 \times 10^{-8} \text{m}^3/\text{kg}$.

TABLE I. THE STATISTIC OF MAGNETIC SUSCEPTIBILITY BY VARIOUS LAWN TYPES

| Type | Magnetic susceptibility ($10^{-8} \text{m}^3/\text{kg}$) | | | Standard deviation |
|---|--|-------|-------|--------------------|
| | Max | Min | Mean | |
| Grassland types | | | | |
| <i>Stipa capillata</i> Linn | 89.70 | 23.97 | 44.76 | 13.556 |
| <i>Achnatherum splendens</i> | 102.57 | 16.91 | 31.65 | 31.428 |
| <i>Blysmus sinocompressus</i> Tang et Wang | 48.33 | 20.40 | 28.74 | 15.664 |
| <i>Kobresia humilis</i> + <i>Kobresia pygmaea</i> | 31.40 | 14.76 | 22.01 | 10.665 |
| Bare land + Arable land | 17.00 | 9.33 | 12.33 | 7.638 |

B. The Correlation between the Magnetic Susceptibility and Heavy Metal

The relationship between the magnetic susceptibility and heavy metal is very close. The industrial production release massive heavy metal ion (such as ions contain Cu, Zn, Pb, Cr and Mn), the coal fired generate the ball-like particulate matter in smoke which contains magnetic components, and then the heavy metal ions attach to the particulate matter to subside to the topsoil, the procedure all of above will increase the magnetic susceptibility and heavy metal in the topsoil simultaneously. (Fig. 4), it shows the positive correlation between magnetic susceptibility and content of Cu, Zn, Pb and Cr ions, the correlation factor R^2 is 0.288, 0.364, 0.098 and 0.212, as the content ions increasing the soil magnetic susceptibility is increasing significantly. The previous research shown[22] that chemical analysis of sediment would reach the same result of highly correlated; however, the negative correlation of Mn ion to the magnetic susceptibility demonstrates the magnetic characteristics also influence by other factors, the high content of Mn in the whole study area show the indivisible relation between the background value and the species genesis.

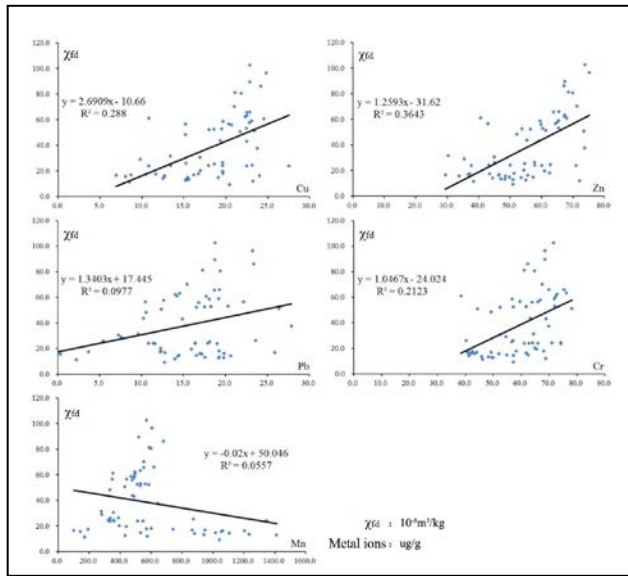


Figure 4. The correlation graphs between magnetic susceptibility and Cu, Zn, Pb, Cr, Mn in topsoil

C. The Spatial Distribution of Heavy Metal

Fig. 5 show the geochemical content of Cu, Zn, Pb, Cr and Mn in topsoil, the increase of heavy metal ion is highly related to atmosphere pump, the local tourism development and the irresponsible garbage and waste water disposal; it is due to closer distance of the 109 national way from Qinghai to Tibet and more dense human activities that the Cu, Zn, Pb, Cr and Mn in topsoil of the south shore is higher the north. Comparing the geochemical content of Cu, Zn, Pb, Cr and Mn in topsoil with The distribution plot of topsoil magnetic susceptibility of Qinghai Lake (Fig. 3), it is significant that the Cu, Zn, Pb and Cr has a high similarity of magnetic susceptibility, it overlap each other well in the around lake region; while Mn is just opposite to the susceptibility. Therefore, the magnetic susceptibility of the top soil is an good index to reveal the soil contamination by heavy metal, and the magnetic susceptibility study are easily adopted, very economical, good in serial continuity, high in resolution. It is suitable for a broader baseline survey in remote west due to hard to access, and then carries out the target researches for the highlight and abnormal area.

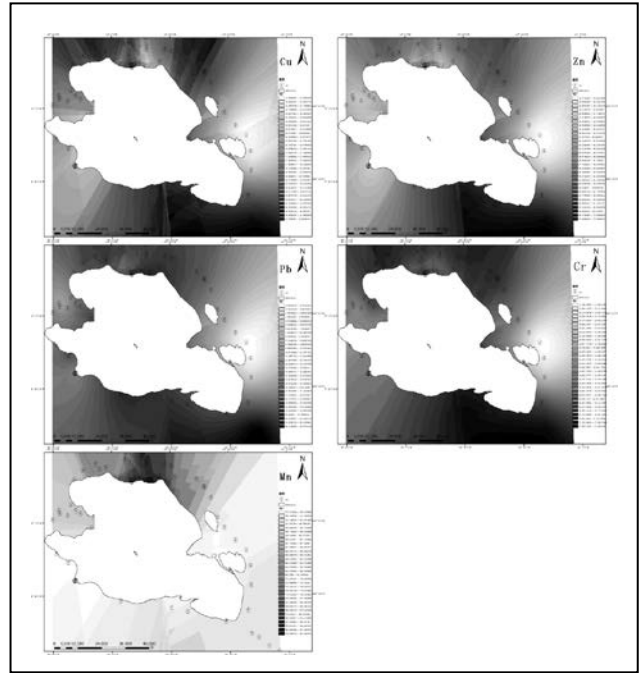


Figure 5. The geochemical content of Cu, Zn, Pb, Cr and Mn in topsoil

IV. CONCLUSION AND DISCUSSION

This article study the soil magnetic characteristics, different magnetic susceptibility in different land type, correlation between heavy metal with magnetic susceptibility, and spatial distribution analysis of Cu, Zn, Pb and etc. to reach following results: (1) the magnetic susceptibility is high in south shore, low in north shore, the spatial difference is due to the high human activities such as: advanced tourism development, high population density in the south shore. (2) Because of the high deposition rate in *Stipa capillata* Linn grassland type and the intensity of the

people and livestock activities, it is may mean magnetic susceptibility value is relatively high. (3) magnetic susceptibility of top soil is highly positive correlated to heavy metal such as Cu, Zn, Pb and Cr, but negative correlated to Mn. (4) the magnetic susceptibility can reflect the heavy metal distribution, in the regional soil monitoring, the simple magnetic susceptibility survey can be adopted for the baseline, and detail research to the abnormal region.

Magnetic susceptibility measurement is a simple convenient and economic approach for the remote and hardly-access west region of China to identify the irregular soil contaminated area and regional the soil monitoring.

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