CHEMICAL ENGINEERING TRANSACTIONS
VOL. 66, 2018
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Songying Zhao, Yougang Sun, Ye Zhou

ISBN 978-88-95608-63-1; **ISSN** 2283-9216
DOI: 10.3303/CET1866106

Study on Spatial Distribution Characteristics of Heavy Metal Chemical Pollution in Jiuzhaigou Scenic Area

Yan Li[a,b]

[a]School of Economic & Management, Northwest University, Xi'an 710127, China
[b]School of Business, Xi'an International University. Xi'an 710077, China
liyan_8108@126.com

Jiuzhaigou scenic area, one of the scenic spots in“World Natural Heritage List”, has a long history and important ecological environment resources. However, with the continuous development of the tourism industry and the impact of earthquake disasters, the problem of heavy metal chemical pollution has become increasingly prominent. This paper takes the spatial distribution characteristics of heavy metal chemical pollution in Jiuzhaigou scenic spot as the research object, adopts the methods of literature analysis, field investigation and mathematical statistics, etc., based on the brief introduction of the general situation of Jiuzhaigou scenic spot and the relationship between earthquake and heavy metal pollution, and adopts field survey. Using the method of regular grid-system deployment, 133 sampling sites in the Jiuzhaigou scenic spot were systematically investigated, and soil properties, pH values, and heavy metal contents and their spatial distribution characteristics were analyzed. The study found that the main heavy metal pollution in the Jiuzhaigou scenic spot are Pb, Cu, and Zn, which are mainly concentrated in roads, residential areas and scenic green areas. Finally, some suggestions on the sustainable distribution of scenic spots were proposed based on the investigation results of the spatial distribution of heavy metal chemical pollution in Jiuzhaigou scenic spot.

1. Introduction

With the accelerating process of modernization and industrialization, while people enjoy the convenience they bring, they are also facing more and more serious problems of environmental pollution. The problem of ecological environment governance has become one of the problems that the current society urgently needs to solve. Among these environmental problems, heavy metal chemical pollution has gradually become the focus of scholars’ research because of its characteristics of wide pollution, concealment of pollution, long duration, hard to be degraded, and accumulation of final disease in the organism (He et al., 1998).
In recent years, earthquake disasters have frequently occurred in China. In secondary disasters such as plagues, floods, and landslides caused by earthquakes, heavy metal pollution caused by heavy metal leakage from chemical companies may cause pollution to the soil and water in the disaster area, which seriously threatens the health of the residents in the disaster-stricken areas. Therefore, the investigation of the spatial distribution of heavy metal chemical pollution in the earthquake-stricken areas is conducive to the rational planning of the disaster areas, reducing the heavy metal pollution that may be caused by the earthquake, and protecting the health of the residents. At present, research on heavy metal pollution in scenic spots in China mainly focuses on the effects of traffic-based tourism activities on scenic plants, soil, water resources, and air pollution (Begum and Ramaiah, 2009), but studies on heavy metal chemical pollution caused by earthquakes are rare.
Based on the above analysis, this paper takes the spatial distribution of heavy metal chemical pollution in Jiuzhaigou as an object of study, and briefly introduces the general situation of Jiuzhaigou Scenic Spot. Based on the analysis of the relationship between earthquake and heavy metal pollution, the method of regular grid-system layout was adopted to collect the soil samples of Jiuzhaigou scenic spot. The soil particle size, pH value and heavy metal elements of the sample is determined. Based on the results of the determination of soil properties and heavy metal content in the Jiuzhaigou scenic spot and the spatial distribution of the study, this paper determines the main heavy metal pollutants within the scenic area: Pb, Cu, Zn, which are mainly in roads,

Please cite this article as: Li Y., 2018, Study on spatial distribution characteristics of heavy metal chemical pollution in jiuzhaigou scenic area, Chemical Engineering Transactions, 66, 631-636 DOI:10.3303/CET1866106

residential areas and scenic green areas. Based on this, this thesis provides several suggestions for the sustainable development of Jiuzhaigou.

2. Theoretical basis

2.1 An overview of Jiuzhaigou scenic spot

Located in the Aba Tibetan and Qiang Autonomous Prefecture of Sichuan Province, Jiuzhaigou (Binbin et al., 2015) is a branch of the headwaters of Jialing River in Yangtze River system. It is located in the transitional zone from the Tibetan Plateau to the Sichuan Basin, and its geographical coordinates are east longitude 100°30´-104°27´, and north latitude 30°35´-34°19. It is 2,000 meters above sea level, spread over virgin forests, with 108 alpine lakes. The terrain is low in the south, high in the north, deep in the valleys, and has a wide range of elevations. It has a humid climate in Plateau.
On August 08, 2017, a 7.0-magnitude earthquake stroke in Jiuzhaigou County, Aba Prefecture, Sichuan Province. The Jiuzhaigou scenic spot was destroyed by the earthquake and the scenic spot stopped receiving passengers. From March 8, 2018, some landscapes of the Jiuzhaigou scenic spot were restored to open.

2.2 The relationship between earthquake and heavy metal pollution

As we all know, earthquakes can trigger a series of secondary disasters, but unlike other secondary disasters that can be directly detected, heavy metal chemical pollution is not easily noticeable, and only when it accumulates to a certain degree and causes adverse effects will it attract people’s attention. Poisonous and harmful substances are often directly or indirectly discharged into rivers, soils, etc., causing pollution to groundwater and surface water, threatening agricultural security, and affecting people’s health and safety through the food chain (Cao et al., 2015). Investigation and study on the spatial distribution and characteristics of heavy metal chemical pollution caused by the earthquake is conducive to post-disaster planning and reconstruction, and is of great significance to the sustainable development of the disaster area.

3. Study on the spatial distribution characteristics of heavy metal chemical pollution in Jiuzhaigou scenec spot

3.1 Sample collection and analysis methods

In this paper, a regular grid-system layout method (Rashid et al., 2012) is used to uniformly fabricate 500m×500m grids in the Jiuzhaigou Scenic Spot. Sampling point grids can be sampled by 500m×500m or 1000m×1000m according to specific land use types. In the grid, sampling points are randomly determined using the method of mixed sampling, and the sampling is performed within a square of 10m×10m. According to the land use status of Jiuzhaigou, 133 samples of different types were collected. Figure 1 shows the diversity survey sample distribution of Jiuzhaigou scenic spot. The soil samples were dried in the room, removed of impurities, rolled, mixed and used (Shi et al., 2013).

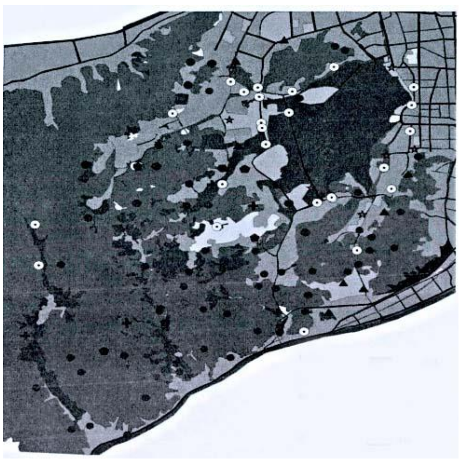


Figure 1: Soil diversity distribution of the sample

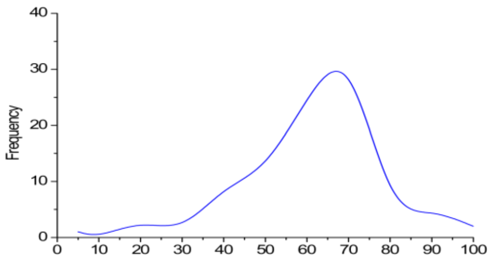
The size of soil particles has big influence on the permeability and fertility of the soil. In this paper, the particle size of soil samples was measured by laser particle size analysis method, and the pH value of soil was measured by potentiometric method (Xi et al., 2015).

The Pb, Cr, Mn and Cu, Zn, V, P, Co, and Ni were respectively digested by HF-HCLO4 heating plate heating method and aqua regia method, and the heavy metal content was determined by inductively coupled plasma emission spectrometry (Yesilonis et al.，2008). Finally，a multivariate statistical analysis and spatial distribution analysis of the heavy metals is conducted by using statistical analysis software, ordinary Kriging interpolation, and Moran1 method (Jiang et al., 2014).

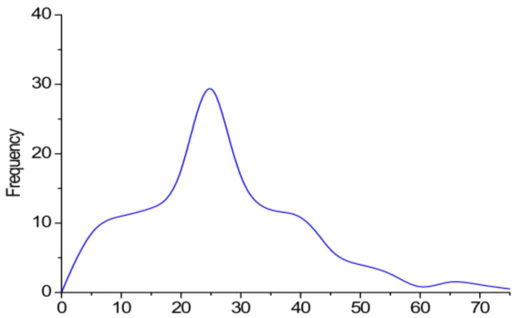
3.2 Results and analysis

1. The general characteristics of the soil in jiuzhaigou scenic area

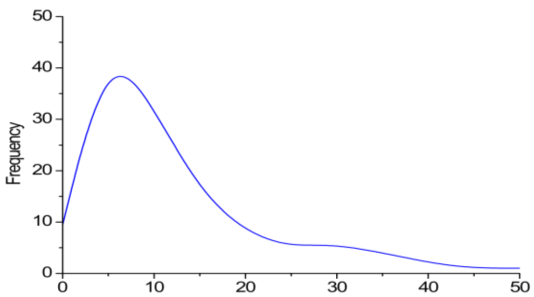
Fig. 2 shows the statistical results of clay texture, grain size and sand content in Jiuzhaigou scenic spot. It can be seen from the figure that the ranking of the soil content percentage (from high to low) in Jiuzhaigou scenic spot is powder, clay, and sandstone, in which the powder is concentrated between 60% and 80%, and the clay is concentrated between 20% and 40%, and the two are basically distributed normally.



(a) *Data distribution of powdered soil in Jiuzhaigou scenic area*



(b) *The distribution of clay soil data in Jiuzhaigou scenic spot*



(c) *Sandstone data distribution in Jiuzhaigou scenic area*

Figure 2: Data distribution of soil clay, grain and sand in Jiuzhaigou scenic area

The pH values of soil have a great influence on heavy metal content (Ogunkunle and Fatoba, 2014). Figure 3 shows the pH distribution of soil in Jiuzhaigou Scenic Area. It can be seen from the figure that the number of samples with soil pH values concentrated at 3.5-5 is larger. This indicates that the soil in the area is acidic, followed by the number of samples of 6.5-8, where the soil is neutral.

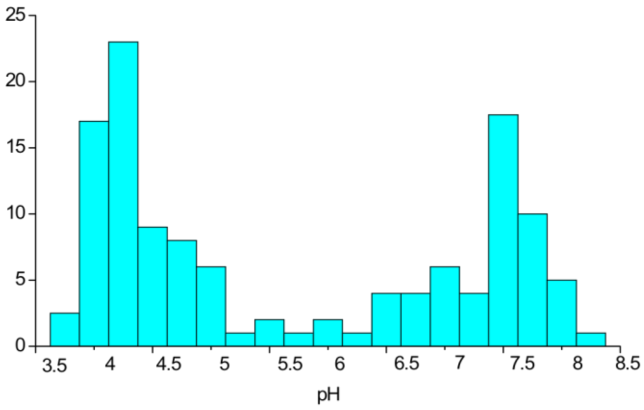


Figure 3: pH distribution in Jiuzhaigou scenic spot

Through correlation analysis of soil texture and pH values with some soil elements, it was found that Zn and Ni were respectively positively correlated and negatively correlated to clay and powder, while pH is significantly negative correlated with Pb and Cr, as well as positively correlated with Mn.

2. Content and distribution of heavy metals Cu, Zn, Pb, Cr, Ni in jiuzhaigou scenic spot

When the heavy metal content of the soil is disturbed, it will break the normal distribution (Li et all, 2014). Therefore, in order to understand the heavy metal pollutants in the Jiuzhaigou area, the multivariate statistical analysis of the probability distribution of the collected sample data and Lilliefors significance calibration (Ji Shen et all, 2007) are shown. Table 1 shows the parameters of the distribution of soil heavy metal elements in Jiuzhaigou scenic spot and its KS test (Stratigea and Katsoni, 2015). It can be seen from the table that the non-normal distribution of heavy metals is more serious and the logarithmic transformation becomes a normal distribution, indicating that the heavy metals in Jiuzhaigou are affected by external factors (Al-Hagla, 2010). This effect may be caused by disturbances like earthquakes and tourism.

Table 1: Distribution of soil heavy metal elements content parameters and K-S test

Name	Raw data			Logarithmic transformation		
	Skewness	Kurtosis	K-SP	Skewness	Kurtosis	K-SP
Cu	4.54	30.8	0.00	0.41	0.66	0.93
Zn	6.01	49.9	0.00	0.56	0.84	0.52
Pb	3.51	16.3	0.00	0.71	1.13	0.42
Cr	7.16	64.7	0.00	1.22	4.98	0.11
Ni	2.91	16.29	0.00	0.18	0.81	0.81

Table 2 shows the comparison of soil heavy metal elements in Jiuzhaigou area with soil background values in Aba Tibetan and Qiang Autonomous Prefecture. It can be seen from the table that Pb, Cu and Zn are higher in the content of heavy metal elements than background values, so Pb , Cu and Zn are the main pollutants of heavy metal chemical pollution in Jiuzhaigou, among which the Pb content is as high as 57.88%, which exceeds the maximum limit of the background value, indicating that the Pb in the Jiuzhaigou scenic spot is the highest in the soil.

Table 2: Comparison between Soil Metal Content and Soil Background Value of Aba Tibetan and Qiang Autonomous Prefecture

——	Cu	Zn	Pb	Cr	Ni
Measured value	26.00±22.2	83.49±92	55.8±46.5	31.09±28.59	22.21±11.32
Background values	18.79±9.79	77.81±70.18	20.68±11.76	59.11±29.51	21.85±9.32
Maximum background value	41.86	111.00	37.21	91.20	41.09
n> Background values (%)	14.28	11.61	57.88	1.54	5.52

3. Spatial distribution of heavy metals Cu, Zn, Pb in jiuzhaigou scenic area

The study on the heavy metal pollution of different land use types is conducive to planning and reconstruction after the earthquake and is of great significance to the sustainable development of the scenic spot. Table 3 shows the comparison of soil heavy metal content in different land use types. The results of the survey showed that among the five types of land use, the three heavy metal pollution types have the highest road content, followed by residential areas and scenic green areas. On the one hand, it is shown that heavy metal chemical pollution may be mainly caused by traffic emissions and human factors. On the other hand, the chemical pollution after the earthquake may deposited with the chemical pollution left by the river after the road scouring.

Table 3: Comparison of Heavy Metal Contents in Soils of Different Land Use Types

Land use type	Cu	Zn	Pb
Tea garden	21.89±12.11b	78.82±88.11b	44.43±17.11ab
Scenic area	27.11±9.89ab	103±62.91ab	56.00±23.19ab
Woodland	17.00±11.41b	50.79±31.59b	45.31±31.29b
Highway side	40.60±35.69a	156.00±154.01a	75.00±67.19a
Residential green area	29.00±23.01ab	86.49±45.89b	59.90±71.09ab

Through the above analysis, we can see that there are severe chemical pollutions in the Jiuzhaigou area, which are mainly caused by post-earthquake impact, traffic and human activities. After the earthquake, the pollution to the scenic eco-environment may be temporary, but the impact of human activities on the ecological environment has always existed. Therefore, in order to ensure the sustainable use of tourism resources and the sustainable development of the ecological environment, the implementation of sustainable development strategies for tourist attractions is an inevitable choice to ensure the resources and environment of the scenic spots. Specifically, we can adopt the principles of “the one causes the pollution is responsible for compensation; the one protects the environment can benefit from it”. We could establish policies for asset management of tourism resources, policies for paid use of tourism resources, and ecological compensation for tourism resources (Borges et all, 2013). Eventually, we promote development with protection and promote protection with development to advance the sustainable development of eco-tourism in Jiuzhaigou scenic area.

4. Conclusion

The non-normal distribution of heavy metals is more serious and the logarithmic transformation becomes a normal distribution, indicating that the heavy metals in Jiuzhaigou are affected by external factors (Al-Hagla, 2010). This effect may be caused by disturbances like earthquakes and tourism.

Through comparison of soil heavy metal elements in Jiuzhaigou area with soil background values in Aba Tibetan and Qiang Autonomous Prefecture. It can be seen that Pb, Cu and Zn are the main pollutants of heavy metal chemical pollution in Jiuzhaigou.

Though the study on the heavy metal pollution of different land use types, it can be concluded that the three heavy metal pollution types have the highest road content, followed by residential areas and scenic green areas. Combining the investigation of the spatial distribution of heavy metal chemical pollution in Jiuzhaigou scenic spot, several suggestions were made for the sustainable development of scenic spots.

References

Al-Hagla K.S., 2010, Sustainable Urban Development in Historical Areas Using the Tourist Trail Approach: A Case Study of the Cultural Heritage and Urban Development (Chud) Project in Saida, Lebanon, Cities, 27(4), 234-248, DOI: 10.1016/j.cities.2010.02.001.

Begum A., Ramaiah M., 2009, Heavy Metal Pollution and Chemical Profile of Cauvery River Water, Journal of Chemistry, 6(1), 47-52, DOI: 10.1155/2009/154610.

Binbin Y., Huimin Z., Tao C., Yijun M., Zucheng W., 2015, Heavy Metal Pollution in Soils from Abandoned Taizhou Chemical Industry Zone in Zhejiang Province, Environmental Technology, 36(23), 2944-2951, DOI: 10.1080/09593330.2014.946095.

Borges C.D.L.L., Castro Í.B., Fillmann G., 2013, Organotin Pollution from Pleasure Craft at Paraty, a Tourist Area of Southeastern Brazil: Amelioration or Interference, Braz.j.oceanogr, 61(3), 177-186, DOI: 10.1590/s1679-87592013000300002.

Cao L., Appel E., Rösler W., Magiera T., 2015, Efficiency of Stepwise Magnetic-chemical Site Assessment for Fly Ash Derived Heavy Metal Pollution, Geophysical Journal International, 203(2), 767-775, DOI: 10.1093/gji/ggv318.

He M., Wang Z., Tang H., 1998, The Chemical, Toxicological and Ecological Studies in Assessing the Heavy Metal Pollution in le a River, China, Water Research, 32(2), 510-518, DOI: 10.1016/s0043-1354(97)00229-7.

Ji S., Liu E.F., Zhu Y.X., Hu S.Y., Qu W.C., 2007, Distribution and Chemical Fractionation of Heavy Metals in Recent Sediments from Lake Taihu, China, Hydrobiologia, 581(1), 141-150, DOI: 10.1007/s10750-006-0523-3.

Jiang X., Teng A., Xu W., Liu X., 2014, Distribution and Pollution Assessment of Heavy Metals in Surface Sediments in the Yellow Sea, Marine Pollution Bulletin, 83(1), 366-375, DOI: https://doi.org/10.1016/j.marpolbul.2014.03.020.

Li F., Huang J., Zeng G., Yuan X., Li X., Liang J., et al., 2013, Spatial Risk Assessment and Sources Identification of Heavy Metals in Surface Sediments from Dongting Lake, Middle China, Journal of Geochemical Exploration, 132(3), 75-83, DOI: 10.1016/j.gexplo.2013.05.007.

Ogunkunle C.O., Fatoba P.O., 2014, Contamination and Spatial Distribution of Heavy Metals in Topsoil Surrounding a Mega Cement Factory, Atmospheric Pollution Research, 5(2), 270-282, DOI: 10.5094/apr.2014.033.

Rashid H., Hasan M.N., Tanu M.B., Parveen R., Sukhan Z.P., Rahman M.S., et al., 2012, Heavy Metal Pollution and Chemical Profile of Khiru River, Bangladesh, Journal of Chemistry, 2(1), 47-52, DOI: 10.1155/2009/154610.

Shi Y., Ge Y., Chang J., Shao H., Tang Y., 2013, Garden Waste Biomass for Renewable and Sustainable Energy Production in China: Potential, Challenges and Development, Renewable & Sustainable Energy Reviews, 22(8), 432-437, DOI: 10.1016/j.rser.2013.02.003.

Stratigea A., Katsoni V., 2015, A Strategic Policy Scenario Analysis Framework for the Sustainable Tourist Development of Peripheral Small Island Areas – the Case of Lefkada-greece Island, European Journal of Futures Research, 3(1), 5, DOI: 10.1007/s40309-015-0063-z.

Xi J., Wang X., Kong Q., Zhang N., 2015, Spatial Morphology Evolution of Rural Settlements Induced by Tourism, Journal of Geographical Sciences, 25(4), 497-511, DOI: 10.1007/s11442-015-1182-y.

Yesilonis I.D., Pouyat R.V., Neerchal N.K., 2008, Spatial Distribution of Metals in Soils in Baltimore, Maryland: Role of Native Parent Material, Proximity to Major Roads, Housing Age and Screening Guidelines, Environmental Pollution, 156(3), 723-731, DOI: 10.1016/j.envpol.2008.06.010.