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Dataset of Heavy Metals in Surface Soil of Yinchuan City, Ningxia Hui Autonomous Region, China

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Abstract: The content of heavy metals in soil is related to ecosystem health and heavy metals in city soils may harm residents' health. The dataset presented here comprises a statistical table of heavy metal elements in surface soils of Yinchuan city and a spatial interpolation map. These data described the contents of Cs, Mg, Pb, Co, Cr, and Ti in surface soils of Yinchuan city as well as the distribution of each element. The correlations between heavy metals were also analyzed in this study, and their abundances were evaluated using the Pollution Load Index (PLI) and Principal Component Analysis (PCA) in order to deduce dominant sources. The concentration of heavy metals in soils of this dataset can help to better understand the status of these pollutants in urban areas and provides a valuable reference for comprehensive soil treatment, the protection of human health, and disease prevention.

Keywords: Yinchuan city; urban area; soil heavy metal; spatial interpolation

1 Introduction

Global change has become a major political, economic, and diplomatic issue around the world. For instance, China designated "the impact of global change on food security and human health" as a major research task and included it into its 12th Five-Year Plan, National Major Research Program on Global Change Research[1]. As one important part of ecosystems, soil exerts a significant impact on global change[2]. With faster urbanization and resulted concentration of various factors (industry, transportation, population), environment problems such as heavy metals in the soil have been worsening[3–4]. Human health can be endangered by inhaling heavy metals in atmosphere (via volatilization), contacting polluted soils, drinking contaminated water, or consuming polluted vegetables[5]. Long-term exposure to environmental heavy metal pollution leads to a variety of acute and chronic diseases, including headaches, nausea, vomiting, and abdominal pain[6]. The elder people and children are more vulnerable to heavy metals[7–8].

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[2] Zhang, M. X., Li, H. Dataset of heavy metals in surface soil of Yinchuan city, Ningxia Hui autonomous region, China [DB/OL]. Global Change Research Data Publishing & Repository, 2018. DOI: 10.3974/geodb.2018.04.10.V1.

Yinchuan is the capital of Ningxia Hui autonomous region. This city comprises a comprehensive industrial region that mainly includes light textile industries and emphasizes the coordinated development of machinery as well as chemical and building material industries. The Yellow River runs through the city. There were 2.191,1 million permanent residents in 2016; all urban residents of Yinchuan generally utilize groundwater. The dataset (HeavyMetalSurfaceSoilYinchuan)[9] encompasses the content of heavy metal elements in soils that are harmful to human health within Yinchuan city and provides a basis for management of city soils, human health protection, and sustainable environment.

2 Metadata of Dataset

The metadata of dataset of heavy metals in surface soils of Yinchuan city, Ningxia Hui autonomous region, China is summarized in Table 1[9]. These metadata include the dataset full name, short name, authors, year, spatio-temporal resolution, data format, data size, data files, publisher, and data sharing policy, etc.

Table 1 Metadata summary of heavy metals in surface soil of Yinchuan city, Ningxia Hui autonomous region, China

Items	Description
Dataset full name	Dataset of heavy metals in surface soils of Yinchuan city, Ningxia Hui autonomous region, China
Dataset short name	HeavyMetalSurfaceSoilYinchuan
Authors	Zhang, M. X. L-8674-2018, Ningxia University, 1014279339@qq.com Li, H. L-8078-2018,Ningxia University, 584001860@qq.com
Geographical region	Yinchuan city (38°22′54.17″N–38°34′44.55″N, 106°2′32.27″E–106°21′56.38″E)
Type of heavy metals	Co, Cr, Cs, Mg, Pb, Ti
Year	2015 Data format .kmz, .shp, .xls Data size 73.8 KB (18 KB after compression)
Data files	The dataset comprises two parts. The first part is the data table of heavy metal elements in surface soils of Yinchuan city: 6_Heavy metal_topsoil_Yinchuan.xls. The second part is the dataset of vector and spatial interpolation graphs of sampling points and research areas, including six .shp files and seven .ai files
Foundation(s)	National Natural Science Foundation of China (41461098)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (data products), and publications (in this case, in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten percent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[10]

3 Data Acquisition and Processing

Sampling points were arranged according to a 3 km by 3 km grid using the software ArcGIS, and a series of theoretical coordinates were determined by combining Google Earth images. The actual latitude and longitude coordinates of each sampling point were recorded using GPS according to the appropriate adjustment of the environment in each case and a diagram

was generated in ArcGIS. Information about each sampling point was recorded in detail; each undisturbed soil sample was extracted indoors in dry air, impurities such as pebbles and grassroots were removed, and materials were sieved at 0.85 mm to measure physicochemical properties. A portion of about 20 g soil for each sample was ground using a vibration grinding mill so that the final particle size was smaller than 200 meshes (0.075 mm) to enable use of a pressure plate. An x-ray fluorescence spectrometer was then used to determine the contents of Co, Cs, Mg, Pb, Cr, and Ti in soil samples. Standard (GSD-12, GSS1) and repeated samples were used for quality control, analysis, and evaluation.

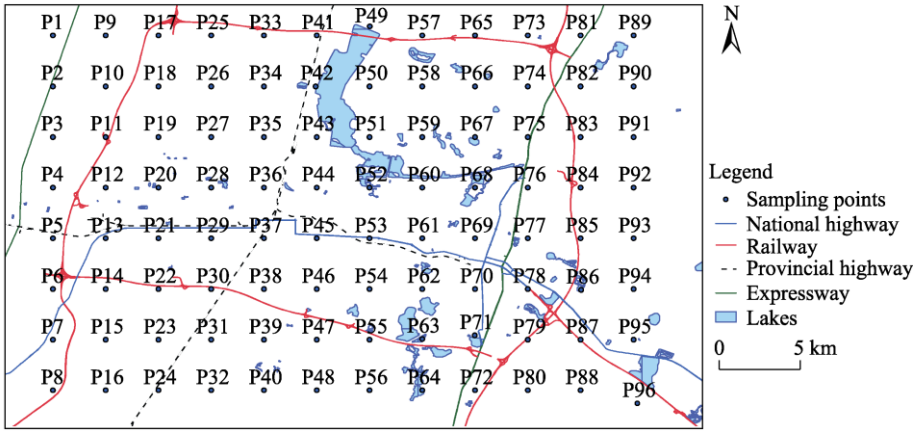

Figure 1 Sketch map to show soil sampling points in Yinchuan city

4 Results

4.1 Descriptive Statistics

Table 2 shows the heavy metal contents in surface soils of Yinchuan city and the background values in Ningxia Hui autonomous region and China. According to the mean value, contents of heavy metals except Pb were higher than the corresponding background value in China, and the content of Ti was much higher than the background values both in Ningxia (regional) and China (national). The values of Co, Cr and Ti at all sampling points were higher than the national background values, and the difference between the minimum and maximum values was large. The national background values of Mg, Cs, and Pb were in the range of their values, indicating that the elements had obvious high-value areas and agglomeration effect.

Table 2 Statistics of six heavy metal elements recorded at sampling points (mg/kg)[9]

Element	Co	Cr	Cs	Mg	Pb	Ti
Minimum value	16.7	66.2	0.1	0.98	12.8	1,189
Maximum value	108.4	143.8	41.3	2.80	49.1	2,428
Arithmetic mean value	37.2	109.1	17.7	3.25	25.0	2,040
Background value in Ningxia[11]	11.5	60	5.4	1.22	20.6	0.35
Background value in China[11]	12.7	61	8.2	0.78	26.0	0.38

4.2 Evaluation of Soil Heavy Metal Pollution

Pollution Load Index (PLI) data used to evaluate soil heavy metal pollution is presented in Table 3. The presence of Ti and Co in surface soils of Yinchuan denoted severe pollution, while Mg corresponded with moderate pollution and Cr, Cs, and Pb marked light pollution.

Table 3 Heavy metal PLI values for surface soils in Yinchuan city

Element	Co	Cr	Cs	Mg	Pb	Ti
PLI	3.16	1.67	1.67	2.67	1.17	3,368.42

4.3 Principal Component Analysis (PCA)

(1) Soil heavy metal content was standardized using standard deviations and a correlation coefficient matrix was calculated (Table 4).
(2) Characteristic values were extracted from the correlation coefficient matrix alongside contribution and cumulative contribution rates of each principal component (PC).
(3) Eigenvectors for eigenvalues were calculated alongside the PC load of each variable (Table 5).

Table 4 A Pearson correlation matrix of heavy metal concentrations in Yinchuan urban topsoil

		Co	Cr	Cs	Mg	Pb	Ti
Pearson's correlations	Co		0	0.32	0	0	0
	Cr	–0.486		0.18	0	0	0
	Cs	–0.048	–0.1		0.448	0.36	0.207
	Mg	–0.583	0.523	0.01		0	0
	Pb	–0.521	0.606	0.04	0.392		0
	Ti	–0.697	0.579	0.09	0.709	0.67	

Table 5 Principal component load of six heavy metal elements

Elements	1	2	3
Co	–0.24	–0.067	0.341
Cr	0.234	–0.217	0.443
Cs	0.011	0.954	0.141
Mg	0.238	0.003	–0.74
Pb	0.236	–0.003	0.801
Ti	0.273	0.088	–0.13
Eigenvalue	3.319	1.033	0.651
Variance	55.31	17.211	10.85
Cumulative variance	55.31	72.52	83.37

The results of this analysis revealed that the cumulative variance of the top three PCs was 83.368%. Data showed that the first PC explained 55.309% of total information and mainly reflected the influence of natural factors on the accumulation of heavy metals in surface soils. The second PC explained 17.211% of total information and was likely the result of mineral and industrial pollution, while the third PC explained 10.848% of total information and was likely sourced from transportation.

4.4 Spatial Distribution Patterns

Figures 2−7 show the spatial distribution of heavy metals in the surface soil of Yinchuan city. The content of Co in the surface soil of Yinchuan city was generally high, and the content in the east and west sides of the city was higher, and the content in the inner city was lower, with an obvious high value zone. Combined with the dataset, the content of Co was 2.93 times of the national background value. The highest value was in P13, and it was 9.43 times of Ningxia background value. The lowest value was in P55, and it was 1.45 times of Ningxia background value.

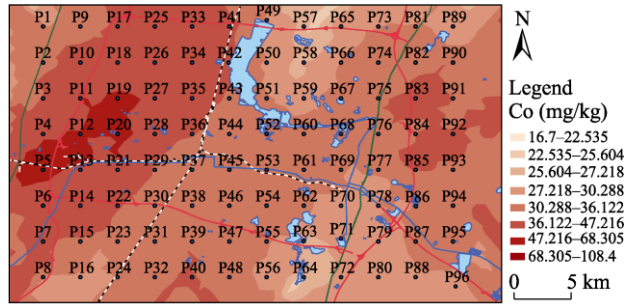

Figure 2 The spatial distribution of Co in surface soils of Yinchuan city

The content of Cr elements was generally high, showing a decreasing trend from east to west. The highest value in the East was in P94, and it was 2.40 times of the background value in Ningxia. The lowest value was in P6, and it was 1.10 times of the background value in Ningxia. The content of Cs was generally high, showing the trend of "high in the center and low in all sides". According to the sampling records, the high value area was near the Yinxing highway. The highest value was in P38, 7.85 times of the background value in Ningxia, and minimum value was in P92, 0.02 times of the background value in Ningxia.

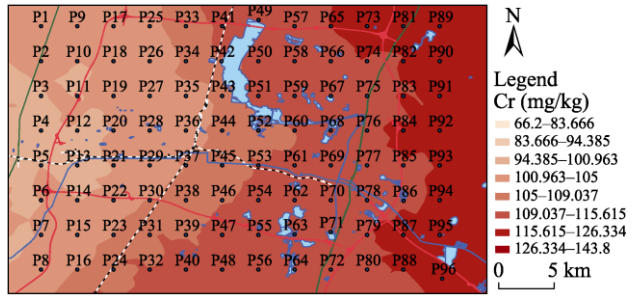

Figure 3 The spatial distribution of Cr in surface soils of Yinchuan city

The Mg element showed a high spatial distribution on both sides of the north and south and low on the east and west sides. The content in the north side was higher than that in the south side, and the difference between the maximum value and the minimum value was very small. The change of element content was relatively gentle.

The content of Pb decreased from east to west, and stripped high-value areas appeared near the expressway. The overall content was equivalent to the national background value, and it was 1.21 times of the background value in Ningxia. The content of Ti elements was far beyond the national background value. The data indicated that the spatial distribution of Ti decreased from the southeast and northeast to the west.

5 Discussion and Conclusion

The dataset on heavy metals in surface soils of Yinchuan city presented here comprised the spatial distribution and main sources of six key elements including Co, Cr, Cs, Mg, Pb, and Ti. The spatial patterns of six heavy metals revealed that there were high-value regions for each element, mainly lying nearby the traffic system and industrial parks. According to the

literature and the analysis of heavy metal elements, it can be inferred that the main source of Co and Ti was influenced by the properties of sandy soils in Ningxia. Heavy metals with the enrichment characteristics, such as Cr, Cs, Mg, and Pb, were mainly from vehicle exhaust emissions, dust, and industrial production. The concentration and analysis of heavy metals in soils in this dataset can help to understand the status of these elements in urban areas and provide a reference for comprehensive soil remediation, the protection of human health, and disease prevention.

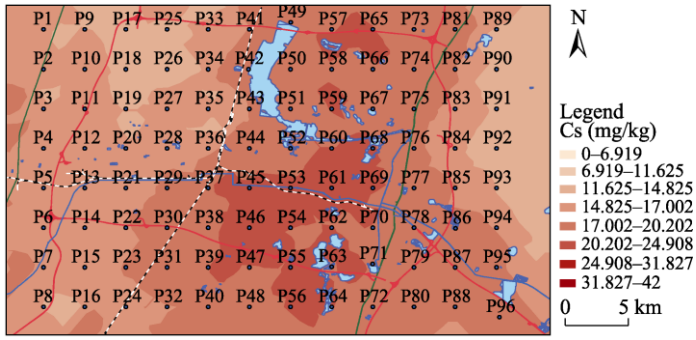

Figure 4 The spatial distribution of Cs in surface soils of Yinchuan city

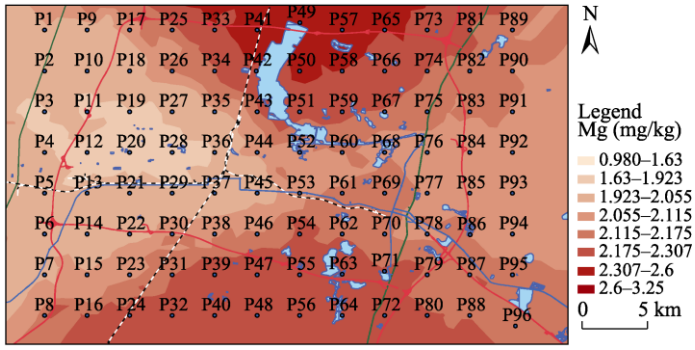

Figure 5 The spatial distribution of Mg in surface soils of Yinchuan city

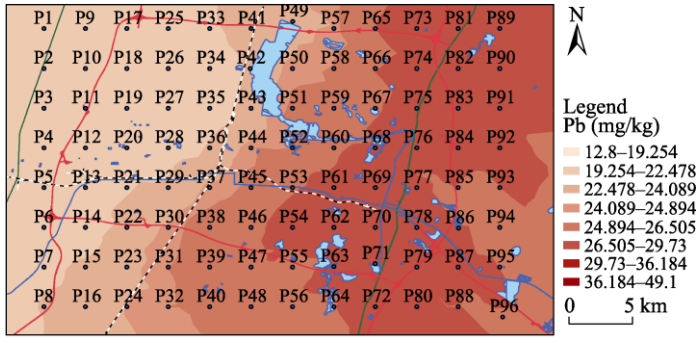

Figure 6 The spatial distribution of Pb in surface soils of Yinchuan city

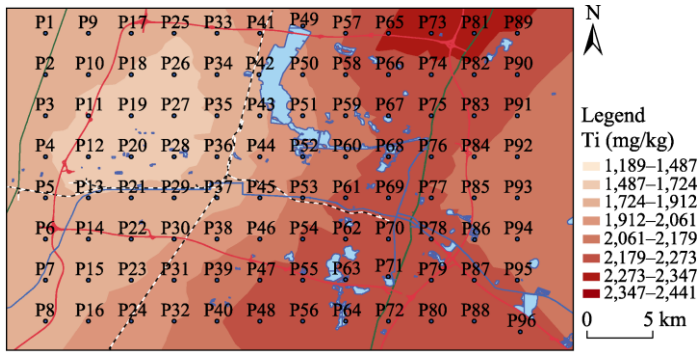

Figure 7 The spatial distribution of Ti in surface soils of Yinchuan city

Author Contributions

Zhang, M. X. designed the dataset algorithms and contributed to data processing and analysis, and Li, H. wrote the data paper.

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