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Factors that influence the spatial distribution of heavy metals in soil of the Yutian County, Xinjiang, China

Yunfei Chen[1,2], *Jinlong* Zhou[1,2,*], *Yinzhu* Zhou[3,**], *Yanyan* Zeng[1,2], and *Ying* Sun[1,2]

[1]College of Water Conservancy and Civil Engineering, Xinjiang Agricultural University, Urumqi, 830052, P.R.China
[2]Xinjiang Hydrology and Water Resources Engineering Research Center, Urumqi, 830052, P.R.China
[3]Key Laboratory of Drinking Water Science and Technology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100049, P.R.China

Abstract. In this study, 1165 surface soil samples for heavy metal analysis were collected in the Yutian County, Xinjiang, China. The factors that influence the spatial distribution of heavy metal elements in soils in the study area were analyzed by means of multivariate statistical analysis, geostatistics, spatial autocorrelation, spatial analysis and GIS technology. Results show that among 1165 soil samples, three of which had As contents greater than the risk screening values. The theoretical models for variation function of Cd and Pb were exponential model, while the theoretical models for variation function of Hg, As, Cr, Cu, Ni and Zn were spherical model. Nugget value of Cd was less than 25%, indicated a relatively strong spatial correlation. Nugget value of other elements ranged between 25% and 50%, indicated significant spatial correlations. The spatial autocorrelation Moran's I index of soil heavy metal contents in the Yutian County was greater than 0. There was a positive spatial correlation distribution in the county scale. The spatial distribution of soil heavy metal contents in the Yutian County showed a general decreasing trend from the center of the study area to surrounding areas. Distribution of soil heavy metal contents in the Yutian County varied in different parent materials, soil types and land use patterns. Hg, As, Pb, Cr, Cu, Ni and Zn in soil derived from the same source, contents of which were affected by soil texture.

1 Introduction

Heavy metal pollution of soil is one of the major forms of soil pollution, which is also a hot issue in the environmental science field [1, 2]. Previous studies on soil heavy metal pollution were mainly focus on source analysis, pollution assessment methods, spatial distribution and pollution remediation, etc. [3-6] As the classical methods applied to soil heavy metals spatial distribution, geostatistics and multivariate statistical methods coupled

* Corresponding author: zjzhoujl@163.com
** Correspondence to: yinzhu_zhou@qq.com (YZ Zhou)

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with GIS technique have been widely used in spatial distribution, influencing factors and sources of heavy metals in soils [7-9]. Yutian County in Hotan District in Xinjiang Uygur Autonomous Region (hereinafter referred to as "Xinjiang") had cultivated area of 335.8 km^2 and cultivated area per capita of 0.116 hm^2, which is one of the key counties of the national poverty alleviation plan. The county is dominated by couples with animal husbandry. Many researches on status and spatial distribution of soil heavy metal pollution in Bosten Lake Basin, Erzis River Basin, Weigan River-Kuqa River Oasis, Boltala River Lake Basin, farmland in Ebinur Lake River Basin, Ruoqiang County, Wusu City, Kuitun City, Dushanzi District of Karamay City and farmlands of various regions (prefectures) in Xinjiang have been carried out at basin scale, county scale and farm scale [10-17]. However, few studies on soil heavy metals in Yutian County, Xinjiang were conducted. The purpose of this paper is to study spatial distribution and influencing factors of soil heavy metals in an oasis area in Yutian County, Xinjiang using the geostatistics, multivariate statistics, and other geochemical tools.

2 Study Area

Yutian County is located in the southern margin of the Taklimakan Desert in the southern part of Tarim Basin and the north foot of the central Kunlun Mountains (Fig. 1). The study area, located in the oasis plain in the central part of Yutian County, belongs to the warm temperate continental arid climate. The study area has an area of 2.42×10^3 km^2, accounting for 6% of the total area of Yutian County. Soil types are mainly shrubby meadow soil, brown desert soil and anthropogenic-alluvial soil. Major Quaternary sediments are alluvial deposits, aeolian deposits and residual deposits. Land utilization types in the study area are dominated by agricultural planting. Major crops in the study area include wheat, rice, maize, walnut, red dates, rose, greenhouse vegetables and cistanche.

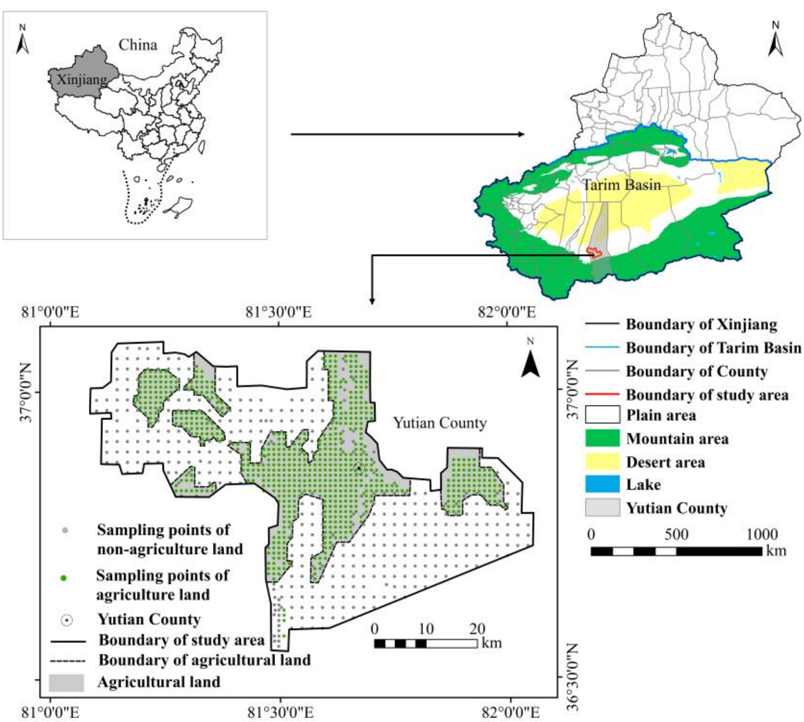

Fig. 1. Study area and locations of sampling points.

3 Material and Method

3.1 Soil Samples Collection and Analysis

In this study, 1165 soil samples were collected in total, 716 of which were collected from agricultural land and 449 of which were collected from non-agricultural land (Fig.1). The contents of Cd, Cu, Ni, Zn and Pb were determined by inductively coupled plasma mass spectroscopy (ICP-MS, X-serise2, Thermo Scientific). The contents of Cr, As and Hg were measured using atomic fluorescence spectrometry (AFS, AFS-9230, Beijing Jitian). The detection limits of ICP-MS for Cd, Cu, Ni, Zn and Pb were 0.0034 mg/kg, 0.54mg/kg, 1.24mg/kg, 0.93mg/kg, 0.84mg/kg, respectively. The detection limits of AFS for Cr, As and Hg were 3.06mg/kg, 0.3mg/kg, 0.0005mg/kg, respectively.

3.2 Data processing

Descriptive statistics and correlation analysis were carried out using SPSS software. Semi-variation function [18] was calculated using GS+9.0 software. Spatial autocorrelation analysis [19] of soil heavy metal contents was carried out using GeoDA software. Related maps and figures were plotted using the ArcGIS 10.4 software.

4 Result and Discussion

4.1 Characteristics of soil heavy metal contents

According to the risk screening values (pH>7.5) in National Soil Environmental Quality - Risk Control Standards for Soil Contamination in Agricultural Land (GB15618-2018), average contents of eight soil heavy metals in Yutian County were generally low. Contents of other elements except for As were lower than the risk screening value. Compared with local soil background values in Xinjiang, the average contents of the other six soil heavy metals except Cd and Hg were lower than local soil background values. Average content of eight soil heavy metals in non-agricultural land were lower than local soil background values. In agricultural land, average contents of Cd, Hg and Cr were higher than local soil background values, while the average contents of other heavy metals were lower than local soil background values [20]. Average contents of soil heavy metals in non-agricultural land were lower than that in agricultural land. In term of variation coefficient (CV), the contents of other seven heavy metals showed moderate variability (10%<CV<100%) while Pb content showed a weak variability (CV<10%).

4.2 Spatial variability of soil heavy metals

Theoretical model used for Cd and Pb variation function was the exponential model, while that for Hg, As, Cr, Cu, Ni and Zn was the spherical model. Nugget value which can reflect variability and measurement error of variate on the minimum sampling scale was used to indicate the spatial variability of soil heavy metals. Nugget value of soil Cd in Yutian County is less than 25%, indicating a strong spatial correlation and less human disturbance, which was mainly affected by natural factors [7, 19]. Nugget value of other seven elements ranged between 25% and 50%, indicating the effect of human activities coupled with natural factors. The R^2 of all heavy metal elements in soil were above 0.605 and RSS were small. The fitting results of theoretical model of variation function of eight soil heavy metals were reasonable [16] with fitting results of R^2>0.605 and RSS>6.24×10^{-9}.

4.3 Spatial autocorrelation analysis of soil heavy metals

Moran's I values of soil heavy metal contents in Yutian County were greater than 0. Soil heavy metal contents had an overall positive spatial correlation distribution on county scale in Yutian County. In general, the soils around high heavy metal contents soils had greater heavy metal contents and vice versa [19]. Local Moran's I index was used as an indicator for local spatial autocorrelation[21]. There were two major spatial clusters of soil heavy metal elements, including high-high pattern and low-low pattern[22]. The high-high spatial clusters of the soil heavy metal contents (including Cr, Hg, As, Pb, Cr, Cu, Ni and Zn) were distributed in the central agricultural land in the study area.

4.4 Spatial distribution of soil heavy metals

The spatial distribution of soil heavy metal contents in Yutian County gradually decreased from the centre to the surrounding areas in the study area. An obvious zonation of soil heavy metal contents between agricultural land and non-agricultural land was observed. Taken Hg as an example (Fig. 2), spatial distribution of soil heavy metal contents predicted by ordinary Kriging interpolation method was basically consistent with local spatial correlation distribution, indicated that soil heavy metal contents had significant spatial heterogeneity and spatial correlation at county scale in Yutian County.

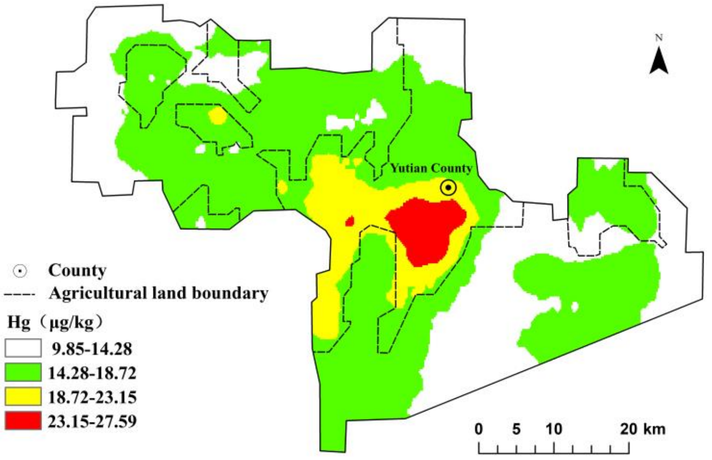

Fig. 2. Spatial distribution of soil Hg contents.

5 Conclusions

In general, soil heavy metal pollution level was relatively low with low soil heavy metal contents in the central oasis area of Yutian county in Xinjiang. The spatial distribution of soil heavy metals had showed a positive correlations on the county scale. Overall, it showed a gradual decrease from the center of the study area to the surrounding area.

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References

1. F. Zang, S.L. Wang, Z.R. Nan, J.M. Ma, Q. Zhang, Y.Z. Chen, Y.P. Li. Geoderma, **305** (2017)
2. G.W. Bryan, W.J. Langston. Environ Pollut **76,** 2 (1992)
3. D.M. You, J.G. Zhou, J.H. Wang, Z.H. Ma, L.G. Pan. Mathem. & Comp. Model., **54,** 3 (2011)
4. Z.Y. Li, Z.W.Ma, T.J. van der Kuijp, Z.W. Yuan, L. Huang. Sci. Total Environ., **468** (2014)
5. G. Machender, D. Ratnakar, L. Prasanna, P.K. Govil. Environ. Earth Sci. **63,** 5 (2011)
6. M. Malandrino, O. Abollino, S. Buoso, A. Giacomino, C.L. Gioia, E. Mentasti. Chemosphere, **82** (2011)
7. H. Cheng, R.L. Shen, Y.Y. Chen, Q.J. Wan, T.Z. Shi, J.J. Wang, Y. Wan, Y.S. Hong, X.C. Li. Geoderma, **336** (2019)
8. L. Fedor, m. Alexander, k. Iryna, V. Yuliia. J.E.A.S, **13,** 8 (2018)
9. E.M.E. Alsbou, O.A. Al-Khashman. Environ Monit Assess, **190,** 1 (2018)
10. J. Pu, L. Ma, J.L.L.·Abuduwaili, W. Liu. Journ, of Agro-Envir, Scien,, **37,**6 (2018) (in Chinese)
11. L. Shi, H.R. Zhou, B. Wen. Envir. Scien. & Tech., **41**, 6 (2018) (in Chinese)
12. M. Yasen, M. Sawut, N. Taxipulati,Y. Abudumiti. Trans. of the Chinese Soc. of Agric. Eng. (Transactions of the CSAE), **33,** 20 (2017) (in Chinese)
13. Z.Y. Ding, L. Ma, J.L.L.·Abuduwaili, W. Liu. Ecol. and Envir. Scien., **26,** 6 (2017) (in Chinese)
14. M. Eziz, A. Mamut, A. Mohammat. Earth and Env., **46,** 1 (2018) (in Chinese)
15. Z.Y. Zhang, J.L.L. Abuduwaili, F.Q. Jiang, M. Anwar. Scient. Geograph. Sinica, **35,** 9 (2015) (in Chinese)
16. Y.Y. Zeng, J.L. Zhou, S.T. Wang, Y. Zheng. Journal of Arid Land Res. and Envir., **31,** 9 (2017) (in Chinese)
17. Y.S. Lai, Y.Y. Ma, W. Wei, S.F. Wang, Z.L. Liu, C.L. Hong, L. Shi. Envir. Chem., **35,** 7 (2016) (in Chinese)
18. W. Wu, D.T. Xie, H.B. Liu. Environ. Monit. Assess., **157** (2009)
19. X.N. Huo, W.W. Zhang, D.F. Sun, H. Li, L.D. Zhou, B.G. Li. Int. J. Environ. Res. Public Health., **8** (2011)
20. H.X. Cheng, K. Li, M Li, K. Yang, F. Liu, X.M. Cheng. Earth Science Frontiers, **21,** 3 (2014) (in Chinese)
21. P.A.P. MORAN. Biometrika., **1-2,** 37 (1950)
22. G. Matheron. Econ Geol, **58,** 8 (1963)