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Effects of prevailing winds on spatial distribution of Pb, Cu and Zn in suburban agricultural soils from Changchun, China

Qiang Liu[1,2]
[1]Northeast Institute of Geography and Agroecology
Chinese Academy of Sciences
Changchun, China
[2]University of Chinese Academy of Sciences,
Beijing, China
liuqiang8752349@163.com

Jingshuang Liu[1]
[1]Northeast Institute of Geography and Agroecology
Chinese Academy of Sciences
Changchun, China
liujingshuang@neigae.ac.cn

Abstract— **The contamination of suburban vegetable soils can affect directly human health and the living quality. In this study an assessment is made to research the impact of prevailing wind on spatial distribution of heavy metals in vegetable field soils from the outskirts of Changchun, China. The study area was divided into four different districts: Southwest(D1), Southeast(D2), Northwest(D3) and Northeast(D4). Total of 50 soil samples were collected to study the accumulation and distribution of Pb, Cu and Zn in D1, D2, D3 and D4. Total Pb, Cu, and Zn concentrations of the urban soils were 31.54 (18.22–46.11), 23.17 (14.48–64.72) and 84.85 (61.20–142.65) mg kg^{-1}, respectively. On average, the orders of the concentration of heavy metals in four districts were D3 > D2 > D4 > D1 for Pb, D1 > D3 > D4 > D2 for Cu and D3 > D1 > D4 > D2 for Zn, respectively. Kriging was used to produce spatial distribution maps for presenting the effects of prevailing wind on heavy metal contamination visually. The identification of the factors that can influence the spatial distribution of heavy metals in suburban vegetable soils is a basis for undertaking appropriate action to protect soil quality.**

Keywords-component; prevailing winds; heavy metal; spatial distribution; districts; suburban vegetable soils

I. INTRODUCTION

Heavy metal pollution in agricultural soils has become an important issue both in developed and developing countries [1, 2]. City soils differ greatly from natural ones as they are more strongly influenced by anthropogenic activities [3]. Some of the areas currently used to grow crops, such as vegetables and corn. The suburban soils for planting vegetables were the most convenient sources for supplying fresh vegetables to citizens. Therefore, it is extremely important to investigate the quality of suburban vegetable soils.

The spatial distribution of pollutants could help scientists in defining the areas where risks are high and then help decisionmakers in identifying locations where remediation efforts should be focused. Further research on the factors of influencing the spatial distribution of pollutants was needed for effectively controlling the pollution. The possible sources of soil metal pollution include atmospheric deposition of dust and aerosol [4], vehicle emissions [5] and various industrial activities [6, 7] and others, and prevailing wind was one of the most important factor of affecting atmospheric deposition.

The purposes of this study were (1) to determine the total concentrations of Pb, Cu and Zn in suburban vegetable soils of D1, D2, D3 and D4 of Changchun; (2) to describe the effects of prevailing wind on the distribution of the studied metals in the soils.

II. STUDY SITE

Changchun, the city of Jilin, is located in northeast China (43°43′ N, 125°19′ E) and covers an area of 20604 km^2, with a population of approximately 7.6 millions inhabitants. The average annual temperature is 4.8℃, and the mean annual precipitation is 570 mm. The prevailing winds blow from the south-west, and the suburban of Changchun was devided into four districts: Southwest(D1), Southeast(D2), Northwest(D3) and Northeast(D4) by using the site of the centre of Changchun (43°43′ N, 125°19′ E) as a reference point(Fig. 1).

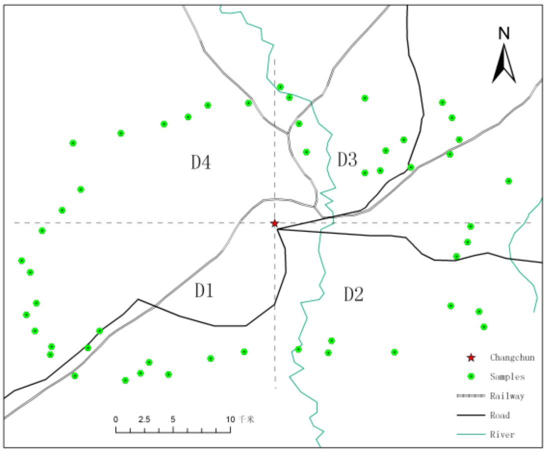

Fig. 1 Locations of four districts and sampling locations of suburban vegetable soils of Changchun, China.

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III. SAMPLING AND CHEMICAL ANALYSIS

Fifty soil samples were collected in the four districts, and the sampling points were randomly distributed in the study area based on a regular grid of 1×1 km, and then screened out the typical vegetable fields to study (Fig. 1.). The topsoil (0-15 cm) was collected. Soils were air-dried and ground in an agate mortar to pass through a 2-mm nylon sieve. A subsample (10 g) of each soil was further ground to pass through a nylon sieve with 0.15-mm openings.

Soil samples were digested with nitric acid (HNO_3) and hydrogen peroxide (H_2O_2) using Method 3050B of the US EPA (1996). Concentrations of Cu, Pb, and Zn in the digestion solution were determined by flame (air-acetylene) atomic absorption spectroscopy (FAAS). A quality control programme, including reagent blanks, replicate samples and standard reference material, was used to assess data precision and accuracy [8]. All glassware,polyethylene labware and Teflon tubes used in the analyses of metals were washed with detergent, acid-soaked and then rinsed thoroughly with deionized water.

IV. RESULTS AND DISCUSSION

A. Heavy metal concentrations in different districts

Table 1 presents the descriptive statistics of the heavy metal concentrations of suburban vegetable soils. The concentration ranges of Pb, Cu and Zn were 18.22–46.11, 14.48–64.72, and 61.20–142.65 mg/kg, with mean values of 31.54, 23.17 and 84.85 mg/kg, respectively.

Mean concentrations of the heavy metals in the vegetable soils decreased in the order of Zn > Pb > Cu for D1, D2, D3 and D4. All of the mean values of the heavy metal concentrations were higher than their background values of Changchun topsoil [9], but lower than the threshold values according to HJ332-2006 in China. Comparisons of mean heavy metal concentrations with natural background concentrations in agricultural soils in the four districts are presented in Fig. 2.

The average concentrations of Pb, Zn and Cu in different areas are shown in Fig. 3. The orders of the concentration of heavy metals in four districts were D3 > D2 > D4 > D1 for Pb, D1 > D3 > D4 > D2 for Cu and D3 > D1 > D4 > D2 for Zn, respectively. Because of the prevailing winds, D3 locates in the downwind area. The highest mean concentrations of Pb and Cu were found in D3 with mean values of 34.16 and 98.31 mg/kg, respectively, indicating that the prevailing winds played an important role in influencing the distribution of Pb and Cu. It also demonstrates that Pb and Zn concentrations in suburban vegetable soils tend to be affected by atmospheric deposition, while Cu may more often be associated with other sources, such as organic fertilizers [10].

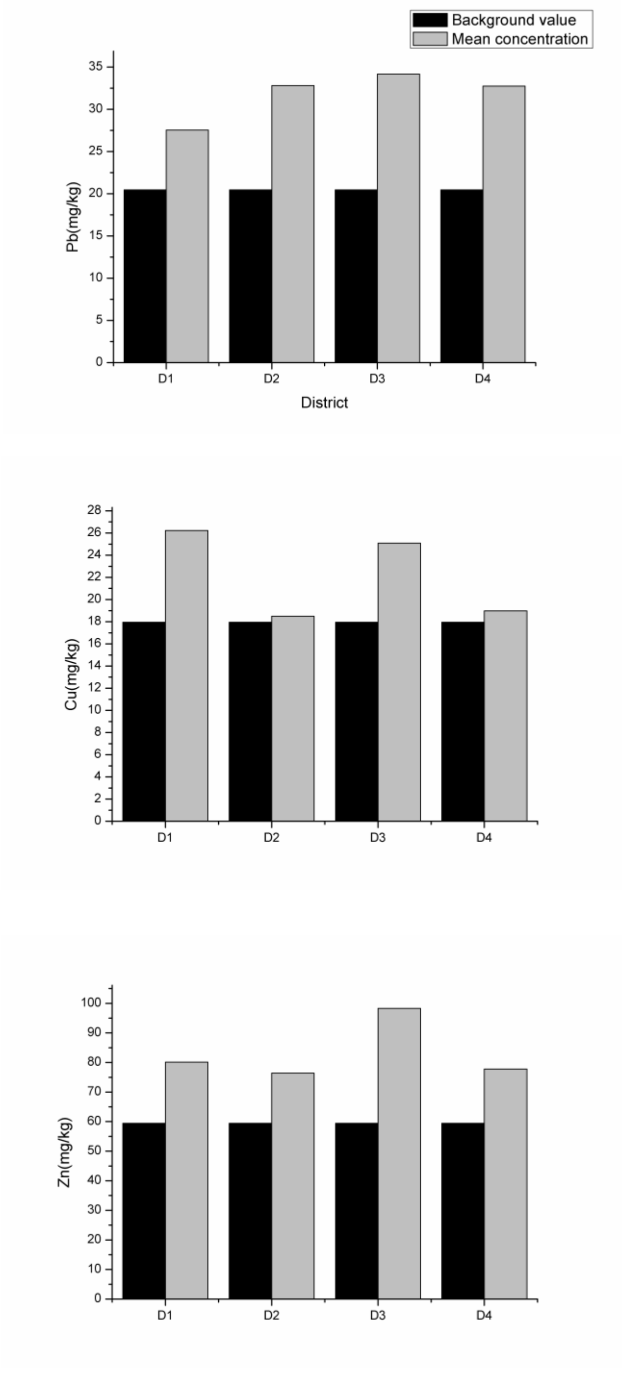

Fig. 2 Comparisons of mean heavy metal concentrations with natural background concentrations in suburban agricultural soils in the four districts from Changchun, China. D1; D2; D3; D4.

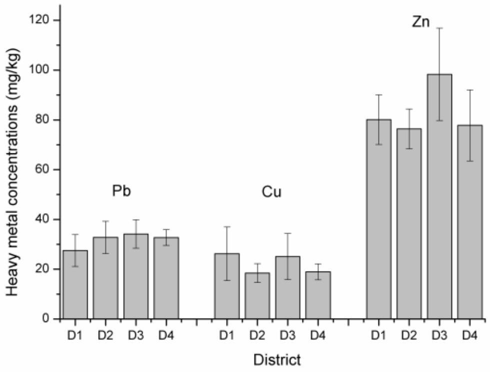

Fig. 3 The mean heavy metal concentrations in suburban agricultural soils in the four studied districts.

Table 1 Heavy metal concentrations of suburban vegetable soils in the districts of Changchun

Metal	District	Item				
		Minimum	***Maximum***	***Mean***	***SD***	***CV (%)***
Pb	***D1***	***18.22***	***41.81***	***27.54***	***6.42***	***23.31***
	D2	***21.93***	***38.63***	***32.80***	***6.49***	***19.79***
	D3	***26.13***	***46.11***	***34.16***	***5.76***	***16.85***
	D4	***28.22***	***37.61***	***32.74***	***3.17***	***9.69***
Cu	***D1***	***19.52***	***64.72***	***26.23***	***10.75***	***40.97***
	D2	***14.48***	***25.88***	***18.50***	***3.77***	***20.36***
	D3	***15.83***	***55.38***	***25.10***	***9.27***	***36.93***
	D4	***15.78***	***26.53***	***18.97***	***3.20***	***16.85***
Zn	***D1***	***68.36***	***100.68***	***80.13***	***9.98***	***12.45***
	D2	***61.20***	***88.82***	***76.37***	***8.02***	***10.51***
	D3	***72.42***	***142.65***	***98.31***	***18.58***	***18.90***
	D4	***66.55***	***113.28***	***77.82***	***14.30***	***18.38***

B. Spatial distribution of heavy metals

GIS software can be used to produce spatial distribution maps and directly reflect the spatial distribution pattern of heavy metals in soils [11]. Spatial distribution maps of Pb, Zn, and Cu in the suburban areas of Changchun City are presented in Fig. 3. Darker colors indicate overlap of higher metal concentrations.

Pb and Zn showed high values in the northeast (D3) and Cu showed high values both in the southwest (D1) and northeast (D3), revealing the same distribution pattern with Fig. 3. The high concentrations of Pb and Zn in northeast were also probably ascribed to atmospheric deposition. Changchun has the good reputation of the automobile city, although petrol with Pb additives has been banned in China, the high concentrations of Pb in the suburban soils may reflect long-term accumulation of heavy metals from traffic emissions [12]. In addition, Zn compounds have been employed extensively as antioxidants and as detergent/dispersant improvers for lubricating oils [13].

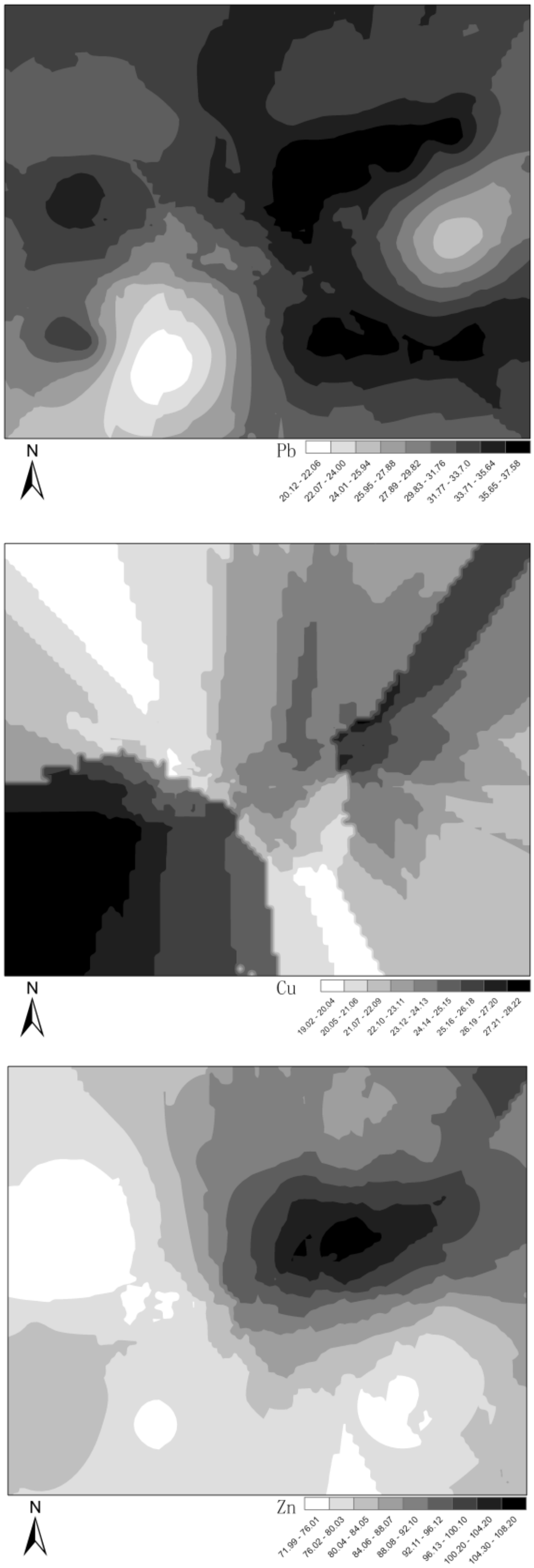

Fig. 4 Estimated Kriging concentration maps for Pb, Cu and Zn in in suburban agricultural soils from Changchun, China

V. CONCLUSION

The results obtained in this work increase our knowledge of the heavy metal contents in suburban agricultural soils from different districts (Southwest, Southeast, Northwest and Northeast) and the impacts of prevailing winds on their spatial distribution. The Pb, Cu and Zn concentrations were higher than their background values, but the overall environmental quality of vegetable soils from Changchun was safe enough for the production of non-polluted vegetables. The prevailing winds played an important role in controlling the distribution of Pb and Zn in the suburban vegetable soils of Changchun. However, the distribution of Cu had weak association with the winds, so further knowledge from other factors would extend and improve the basis for undertaking appropriate action to protect soil quality.

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REFERENCES

[1] Nicholson F A, Smith S R, Alloway, Carlton-Smithd C, Chambers B J, "An inventory of heavy metals inputs to agricultural soils in England and Wales," Science of the Total Environment, pp. 205–219, 2003.

[2] Micó C, Recatalá L, Peris M, Sánchez J, "Assessing heavy metal sources in agricultural soils of an European Mediterranean area by multivariate analysis," Chemosphere, pp. 863–872, 2006.

[3] Bullock P, Gregory PJ, Soils in the urban environment, Oxford: Black well, 1991.

[4] Simonson, R W, "Airborne dust and its significance to soils," Geoderma, pp. 1–43, 1995.

[5] Surthland, R A, Tolosa, C.A., Tack, F.M.G., Verloo, M.G, "Characterization of selected element concentrations and enrichment ratios in background and anthropogenically impacted roadside areas," Arch. Environ. Contamin. Toxicol, pp. 428–438, 2000.

[6] Krishna, A K, Govil, P K, "Heavy metal distribution and contamination in soils of Thane Belapur industrial development area, Mumbai, Western India," Environ. Geol, pp. 1054–1061, 2005.

[7] Li, M S, Luo, Y P, Su, Z Y, "Heavy metal concentrations in soils and plant accumulation in a restored manganese mineland in Guangxi, aouth China," Environ. Pollut, pp. 168–175, 2007.

[8] Sutherland, R A, Tolosa, C A, "Multi-element analysis of road-deposited sediment in an urban drainage basin, Honolulu, Hawaii," Environmental Pollution, pp. 483–495, 2000.

[9] Meng X X, Li S Z, Soil Background Values of Jilin Province, Beijing: Science Press, 1995, (in Chinese).

[10] Zhu Y J, Zheng Y M, He J Z, Li L H, Zhang L, "Risk assessment of pig manure Cu-contamination of black soil in northeast China," Chinese Journal of Applied Ecology, pp. 2751–2756, 2008.

[11] Webster, R, Oliver, M A, Geostatistics for Environmental Scientists. John Wiley and Sons, Chichester, 2001.

[12] Guo G H, Lei M, Chen T B, Song B, Li X Y, "Effect of road traffic on heavy metals in road dusts and roadside soils," Acta Scientiae Circumstantiae, pp. 1937–1945, 2008.

[13] De Miguel E, Llamas J F, Chac´on E, Mazadiego L F, "Sources and pathways of trace elements in urban environments: a multi-elemental qualitative approach. Science of the Total Environment," pp. 355–357, 1999.