JOURNAL OF ENVIRONMENTAL SCIENCES XX (2017) XXX–XXX

Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/jes

JES JOURNAL OF ENVIRONMENTAL SCIENCES www.jesc.ac.cn

Effects of urbanization on heavy metal accumulation in surface soils, Beijing

Meie Wang[1], *Rui Liu*[1], *Weiping Chen*[1,*], *Chi Peng*[1], *Bernd Markert*[2]

1. *State Key Laboratory of Urban and Regional Ecology, Research Centre for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China. E-mail: mewang@rcees.ac.cn*

2. *Environmental Institute of Scientific Networks, 49733 Haren, Germany*

ARTICLE INFO

Article history:
Received 15 April 2016
Revised 20 May 2016
Accepted 18 November 2016
Available online xxxx

Keywords:
Urban soils
Human disturbance
Zn
Impervious land
Population density

ABSTRACT

Urbanization processes affect the accumulation of heavy metals in urban soils. Effects of urbanization on heavy metal accumulation in soils were studied using Beijing as an example. It has been suggested that the ecological function of vegetation covers shifting from natural to agricultural settings and then to urban greenbelts could increase the zinc (Zn) concentrations of soils successively. The Zn concentration of urban soils was significantly correlated to the percentage of the impervious land surface at the 500 m × 500 m spatial scale. For urban parks, the age or years since the development accounted for 80% of the variances of cadmium (Cd) and Zn in soils. The population density, however, did not affect the heavy metal distributions in urban soils. To conclude, the urban age turned out to be a notable factor in quantifying heavy metal accumulation in urban soils.

Introduction

One of the focused works of urban ecology is to track the flow of pollutants in the city environment and to understand the interplay between artificial and natural elements, such as how urbanization affects the accumulation of heavy metals in urban soils (Humphries, 2012). Various works have been done to explore the distribution of heavy metals in urban soils as well as their impacting factors (Yuan et al., 2014; Lv et al., 2013), of which land use patterns, intensity of anthropogenic activities, legacies of pollution, and distance to emission sources were primary causative factors (Luo et al., 2012). Soils in residential and recreational sites in cities are often reported to have high levels of cadmium (Cd), lead (Pb), zinc (Zn), and copper (Cu) (Madrid et al., 2002). Traffic and industrial emissions are identified as the main sources for the accumulation of heavy metals in urban soils (Faciu et al., 2012; Hamzeh et al., 2011; Li et al., 2004). Yet the accumulations would be significantly higher in the older and more intensely urbanized parts of a city (Madrid et al., 2002). Schwarz et al. (2012) reported that soil lead was strongly related to housing age in residential sites.

How do the heavy metal deposition patterns of urban soils relate to urbanization processes? Chen et al. (2010) and Madrid et al. (2002) found that the heavy metal concentration of the soils increased with the traffic densities of the surroundings. However, they were unable to obtain statistically significant regression between dependent variable (*i.e.*, concentrations of heavy metals in soils) and the independent variable (*i.e.*, traffic density). The inconsistency caused by differences of the variables' spatial scales prevented the establishment of a quantitative relationship between those two types of variables. The heavy metal concentration of soils was measured in the scale of soil sampling plots (Schwarz et al., 2012), while parameters characterizing the urbanization processes were related to the larger

* *Corresponding author*. E-mail: wpchen@rcees.ac.cn (Weiping Chen).

http://dx.doi.org/10.1016/j.jes.2016.11.026
1001-0742/© 2017 The Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences. Published by Elsevier B.V.

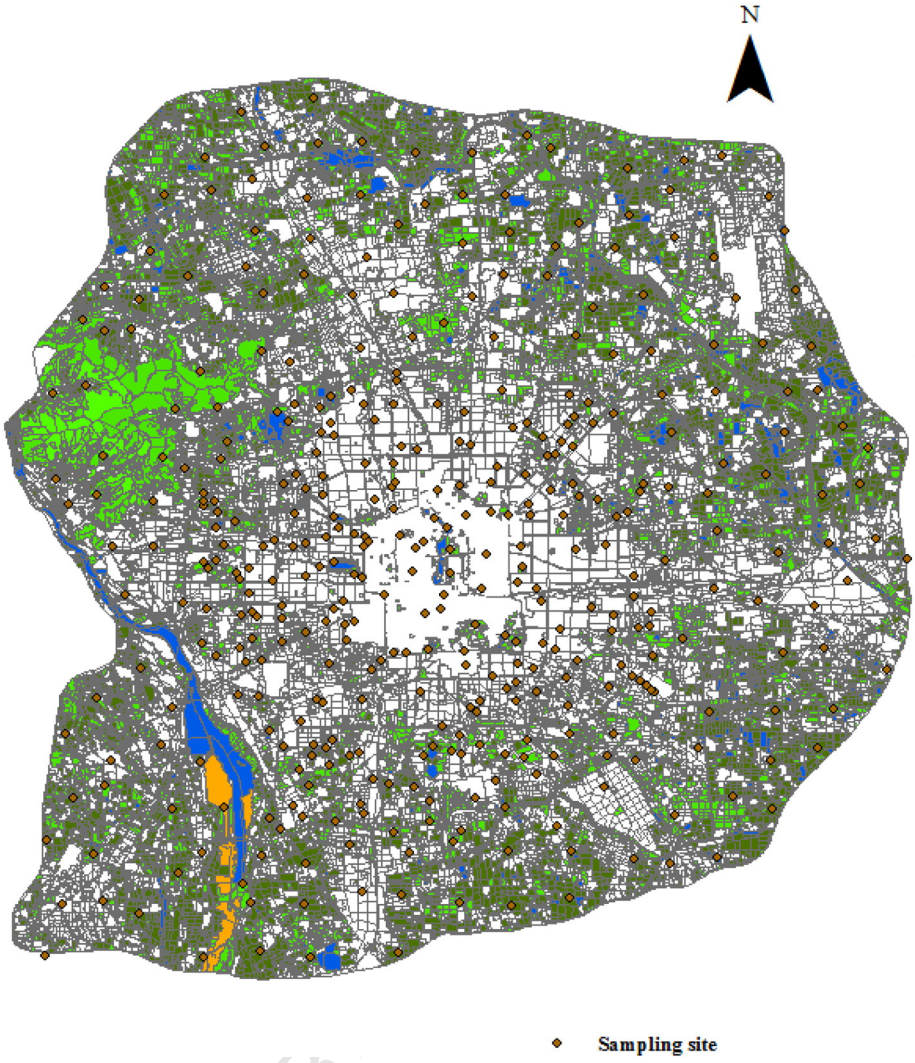

Fig. 1 – The map of soil sampling in Beijing.

spatial scales of the precinct, district, or region. It would be imperative to screen and select measurement parameters that would provide compatible attributes on both dependent and independent variables.

As the natural and agricultural lands were transformed through urbanization processes, the ecological functions of soils shifted from production and accumulation of biomass to be receptacles of pollutants. Impervious land surface and population density, therefore, would be most reflective of the extent and length of the urbanization. We hypothesized that the impervious land surface, urban age, and population density in the district scales would be predictors of the heavy metal concentration of soils on a parcel scale. The purpose was to demonstrate the efficacy of the above-mentioned urban development indices in predicting the accumulation of heavy metals in urban soils. What's more, interactions between human activity and natural resources were studied and explained in this work, which is an important issue in urban ecology.

1. Materials and methods

1.1. Study area soil sampling

The metropolitan Beijing of 2200 plus km^2 is encircled by six concentric ring roads, with the center being the oldest and the

Table 1 – Heavy metal concentrations (mg/kg) of green land soils in Beijing that had different ecological functions.

Ecological function	Observation	Cd	Cu	Pb	Zn
Urban	178	0.136 ± 0.320a	26.7 ± 15.3a	22.2 ± 16.7a	83.1 ± 33.6a
Agriculture	66	0.140 ± 0.131a	29.0 ± 15.4a	21.8 ± 7.80a	72.4 ± 22.8b
Undisturbed	33	0.119 ± 0.060a	28.0 ± 11.3a	22.7 ± 7.80a	77.1 ± 30.5ab

Different letters denote the significance difference at 0.05 level.

Please cite this article as: Wang, M., et al., Effects of urbanization on heavy metal accumulation in surface soils, Beijing, J. Environ. Sci. (2017), http://dx.doi.org/10.1016/j.jes.2016.11.026