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Environmental contamination of heavy metals from zinc smelting areas in Hezhang County, western Guizhou, China

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Abstract

Total heavy metal (Cd, Cr, Cu, Pb and Zn) concentrations were evaluated in smelting waste, soil, crop and moss samples collected from the Hezhang artisanal zinc smelting areas, Guizhou, China. Soil samples from the cornfield near the smelting sites contained extremely high Cd (5.8–74 mg kg^{-1}), Pb (60–14,000 mg kg^{-1}) and Zn (260–16,000 mg kg^{-1}) concentrations. Elevated heavy metal concentrations were also found in corn plants and total Pb (0.80–1.5 mg kg^{-1}) and Cd (0.05–0.76 mg kg^{-1}) concentrations in corn grain have totally or partially exceeded the national guidance limits for foodstuff. Thus, the soil-to-crop transfer of heavy metals might pose a potential health risk to the local residents. Similar to the high heavy metal levels in soil and corn, Cd, Cr, Cu, Pb and Zn concentrations in moss samples collected from the smelting sites ranged from 10 to 110, 10 to 55, 26 to 51, 400 to 1200 and 330 to 1100 mg kg^{-1}, respectively, exhibiting a local spatial pattern of metals deposition from the atmosphere. Based on examination of Zn/Cd and Pb/Cd ratios of the analyzed samples, we have distinguished between the flue gas dust derived and smelting waste derived metals in different environmental compartments.

Keywords: Zinc smelting activity; Heavy metal; Soil; Crop; Moss; Source attribution; Hezhang; China

1. Introduction

Nonferrous metals smelting is considered as one of the most important anthropogenic sources of heavy metal pollution to the environment worldwide (Rieuwerts and Farago, 1996; Stercke-man et al., 2000; Barcan, 2002; Cui et al., 2004; Bacon and Dinev, 2005). Such pollutants have been attributed to emissions from both smelter stacks and fugitive sources such as stockpiles and waste heaps (Rieuwerts and Farago, 1996). Smelting emitted metals are transferred to environmental compartments, such as water, soil and plant, and can eventually enter the human bodies through food chains or direct ingestion, which will pose a threat to human health. Many studies have reported the high levels of Pb and Cd in the blood and urine of people, particularly children living close to nonferrous metal smelters (Silvany-Neto et al., 1989; Ariane et al., 2001; Fischer et al., 2003; Cui et al., 2005).

Since the 17th century, artisanal zinc smelting using indigenous methods had been widely applied in Hezhang County located at western Guizhou Province, SW China. The zinc smelting activities were completely ceased in 2004 due to the concern of environmental pollution. During the long-term zinc smelting activities in Hezhang, huge quantities of exhaust gases containing many kinds of heavy metals had been released into air, and significant quantities of smelting wastes had been produced into piles and spoil heaps. Feng et al. (2004) and Bi et al. (in press) estimated that approximately 50 ton of Hg and 450 ton of Cd were released into the atmosphere from the zinc smelting activities in Hezhang, from 1989 to 2001. Previous studies related to metal contamination to the local environment were conducted at Hezhang district, and data shown that the local surface water, air and soil compartments were seriously contaminated with heavy metals (Shen et al., 1991; Yang et al.,

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2003; Wu et al., 2002; Feng et al., 2004, in press). However, these researches focused only on limited individual samples, and the impacts of metal contamination on the ecosystem have not been fully discussed.

In this study, we for the first time systemically measured heavy metal (Cd, Cr, Cu, Pb and Zn) concentrations in smelting waste, soil, crop and moss compartments at zinc smelting areas in Hezhang for the following purposes: (1) delineate the extents of heavy metal contamination and assess their potential health risk to the local residents related to the zinc smelting activities; (2) distinguish heavy metal origin of different sample compartments by using Zn/Cd and Pb/Cd ratios.

2. Methods

2.1. Study area

Hezhang County (104°10′–105°03′E, 26°46′–27°28′N) is situated at about 340 km west of Guiyang, the capital of Guizhou Province. It lies on the Yunnan-Guizhou Plateau with altitudes varying from 1230 to 2900 m above sea level. Its climate represents a typical subtropical humid monsoon with an average temperature of 13.4 °C and an average annual rainfall of 854 mm. The main soil types are ultisol and limestone soil, and the main crop is corn plant with planting area up to 80%.

All artisanal zinc smelting furnaces were distributed along rivers and valleys in an area <150 km^2 around Magu in Hezhang county. Five smelting areas including Xinguanzhai-Dapingzi, Heinizhai, Haozidong, Zhaizichang and Tianqiao were selected in this study (Fig. 1 and Table 1). Xinguanzhai-Dapingzi site is relatively open, and about 180 zinc smelting furnaces were distributed along rivers in 2002. This site has a relatively long history of artisanal zinc smelting activities since 1980s. At Heinizhai, about 430 artisanal zinc smelting furnaces were densely distributed along a narrow valley in 400 m distance with downwind direction open in 2002. The zinc smelting activities initiated at this site in 1996. Haozidong is a close and narrow valley in which about 240 zinc smelting furnaces were densely distributed in 2002. Zinc smelting activities started at this site from early 1990s. Zhaizichang located in a relatively open valley has a long history of zinc smelting activities since 1950s. Only a few zinc smelting furnaces were found here in 2002. Tianqiao, a relatively open area, has the longest history of zinc smelting activities since the 17th century. Only a few zinc smelting furnaces were distributed along a river in 2002.

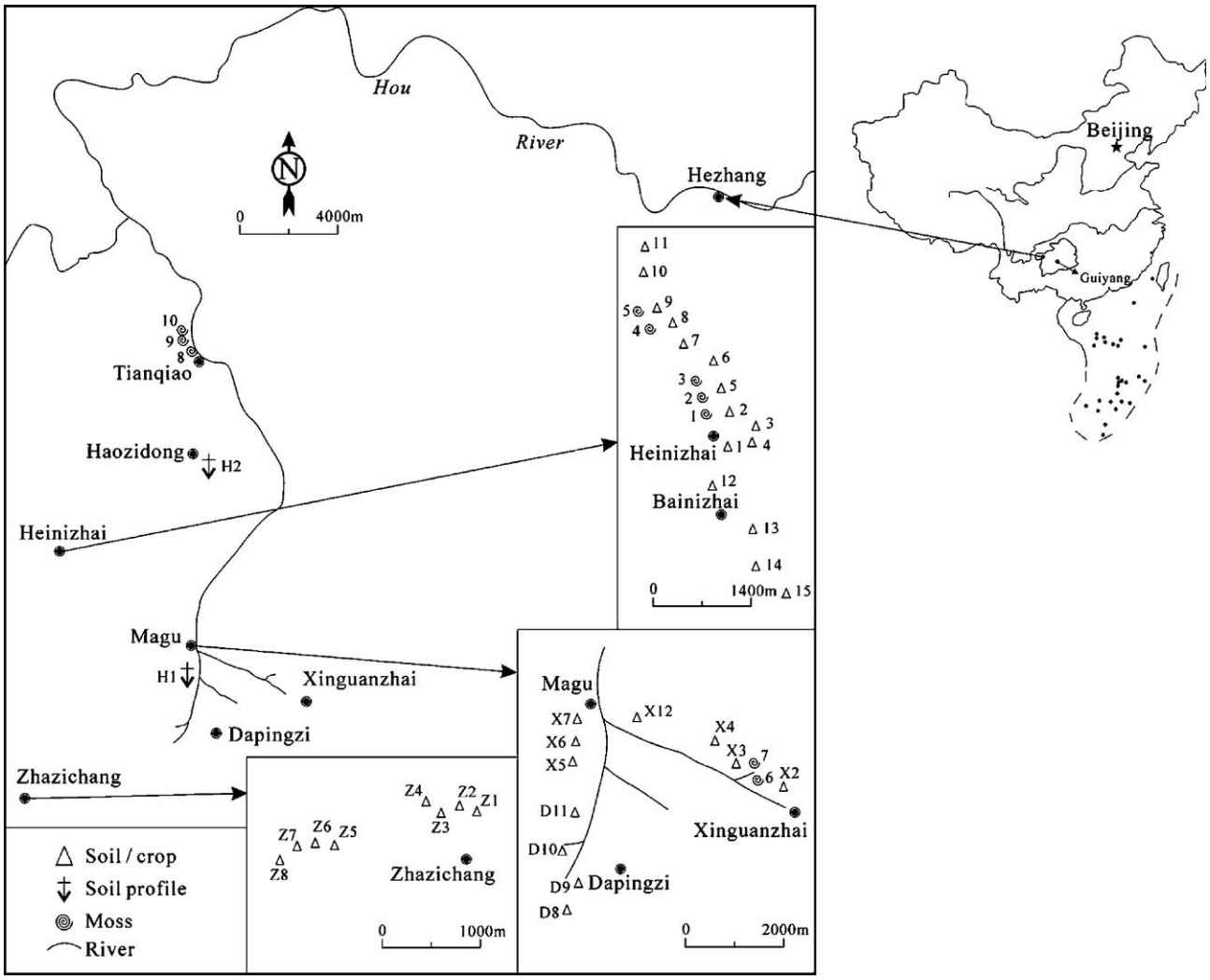

Fig. 1. Sampling locations in the study area.