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Environmental contamination of mercury from Hg-mining areas in Wuchuan, northeastern Guizhou, China

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Mercury mining activities in Wuchun, Guizhou, China have resulted in seriously mercury contamination to the local environment.

Abstract

Total Hg and methyl-Hg were evaluated in mine wastes, soils, water, and vegetations from the Wuchuan Hg-mining areas, Guizhou, China. Mine wastes contain high total Hg concentrations, ranging from 79 to 710 μg g^{-1}, and methyl-Hg from 0.32 to 3.9 ng g^{-1}. Total Hg in soil samples range from 0.33 to 320 μg g^{-1} and methyl-Hg from 0.69 to 20 ng g^{-1}. Vegetations present a high average total Hg concentration of 260 ng g^{-1}, which greatly exceeds the maximum Hg concentration of 20 ng g^{-1} recommended by the Chinese National Standard Agency for food sources. The rice samples contain elevated methyl-Hg concentrations, ranging from 4.2 to 18 ng g^{-1}. Stream water collected from Hg-mining areas is also contaminated, containing Hg as high as 360 ng l^{-1}, and methyl-Hg reaches up to 5.7 ng l^{-1}. Data indicate heavy Hg-contaminations and significant conversion of methyl-Hg in the study areas.

Keywords: Mercury; Methylmercury; Mine waste; Soil; Stream water; Vegetation; Hg mining activity; Wuchuan; China

1. Introduction

Hg is a highly toxic element because of its accumulative and persistent character in the environment and biota. Its toxicity always depends on chemical forms (Clarkson, 1998). Organic Hg compounds, such as methylmercury (methyl-Hg), are water-soluble and have strong abilities of bioaccumulation in the food chain. Organic Hg is, in general, more toxic to living organisms than inorganic forms. However under certain conditions, inorganic forms can be converted to organic forms (WHO, 1990; Boening, 2000), and the primary concern about Hg is the conversion from inorganic Hg to methyl-Hg, the most case of chronic and acute human Hg poisoning (e.g. Minamata disease). Therefore, Hg was and will always be present in acute environmental problem owning to its methylation processing and the biogeochemistry of methyl-Hg has currently received considerable attention.

The mining and retorting of cinnabar ores is one of the most important Hg contaminant sources worldwide. Special attention has been paid to the ecological effects of Hg related to Hg-mined areas: Almadén (Berzas Nevado et al., 2003; Higueras et al., 2003; López Alonso et al., 2003; Gray et al., 2004) and Asturias (Loredo et al., 1999, 2005) in Spain; and Carson River and Humboldt River System (Bonzongo et al., 1996; Rytuba, 2000; Gray et al., 2002a,b) and Kuskokwim Mountains Region (Gray et al., 2000; Bailey et al., 2002) in North America; and Idrija (Gosar et al., 1997; Hines et al., 2000; Horvat et al., 2002) and Gulf of Trieste (Covelli et al., 2001) in the Mediterranean area; and Wanshan (Horvat et al., 2003; Qiu et al., 2005) and Palawan (Gray et al., 2003) in Asia.

China is rich in Hg and the reserves of Hg ranks the third in the world. The most important Hg production centre in China

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is Guizhou province. The cinnabar deposits in the province, approximately 80 000 tons of metal Hg, represents approximately 70% of the total in China (Qu, 2004). Wuchuan Hg mine is one of most important Hg production areas in Guizhou (Fig. 1). It has a long history of Hg production for approximately 400 years and more than 4070 tons of metal Hg had been produced. The large scales of Hg-mining activities in Wuchuan began in 1949 and were shut down in 2003. However, the Hg-mining activities using small-scale artisanal mining technique always exist in the area and are still alive (Fig. 2). During the long term of Hg-mining activities in Wuchuan, significant quantities of gangues, ore tailings, and ignited residues have been produced into piles and spoil heaps. Almost all of the rejected materials especially introduced by those small scales of Hg-retorts were distributed in stream banks and flood plain. To date, few geochemical studies relating to Hg contamination to the local environment have been conducted at the Wuchuan district (Qu, 2004). The objectives of this study were to (1) determine the extent of Hg contaminations in mine wastes, soils and crop plants, (2) determine the speciation and dispersion of Hg in surface waters, and (3) assess the extent of methyl-Hg contaminations in the Wuchuan Hg-mining district.

2. Experimental

2.1. Study area

The Wuchuan district (E: 107°31′ ~ 108°31′, N: 28°11′ ~ 29°05′) is part of a hilly and karstic terrain, ranging in elevation from 325 to 1743 m. Its climate presents a typical subtropical humid monsoon with an average temperature of 15.5 °C and an average annual rainfall of 1272 mm. Hongdu River is a large river in Wuchuan, which finally flows into Wujiang River, the biggest upper tributary of the Yangtze River. Most of the historical/active Hg-retorts and mining activities are distributed along the tributaries of the Hongdu River and the drainage emanating from the Wuchuan mining areas runs into those tributaries. Fish in those tributaries are rare or absent.

Hg mineral deposits in Wuchuan are located in a belt containing numerous Hg mines, including Luoxi, Laohugou, Sankeng, and Taiba (Fig. 2). Similar to most of Hg mines worldwide, the dominant ore mineral is cinnabar, but pyrite and other metal sulfide minerals are rare. Previous Hg-mining activities on a large scale primarily conducted at Luoxi and Laohugou Hg mines. The biggest Hg processing facility in

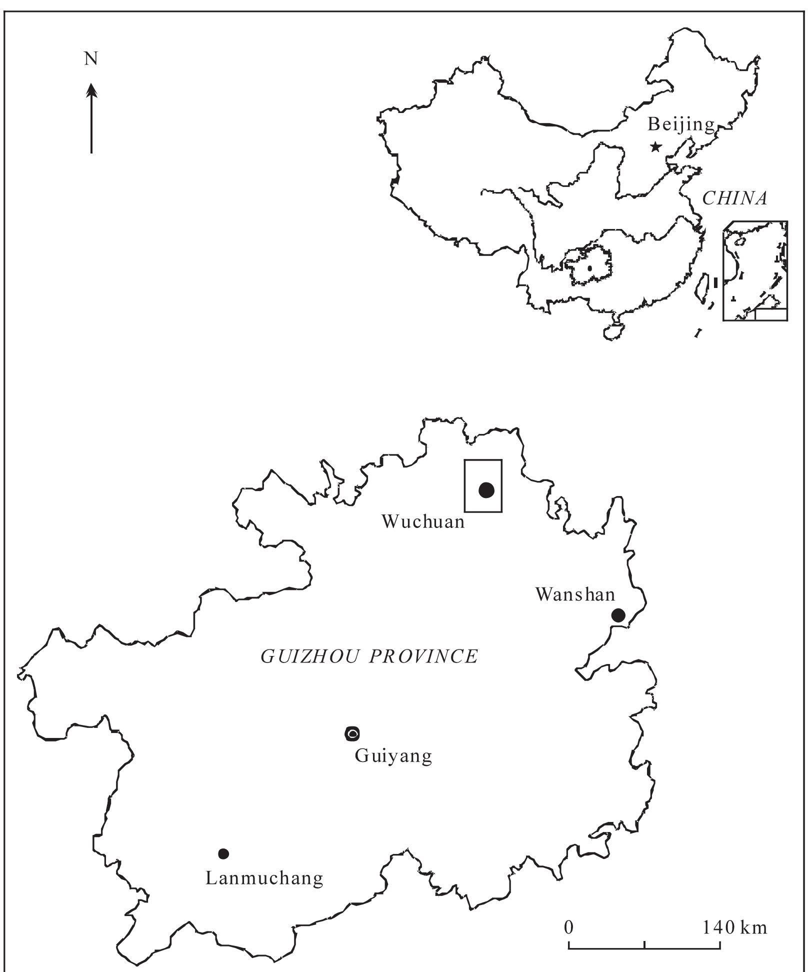

Fig. 1. Map of Guizhou province with the study areas identified.