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Assessment of soil contamination with Cd, Pb and Zn and source identification in the area around the Huludao Zinc Plant

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ABSTRACT

The distribution characteristics of heavy metals (cadmium (Cd), lead (Pb) and zinc (Zn)) in the natural soil profiles around the Huludao Zinc Plant (HZP), an old industrial base in Northeast China, were analyzed. The pollutant source was identified using ^{210}Pb isotope technique to evaluate the geochemical characteristics of Pb and the historical production records of HZP. The results indicated: dust precipitation from HZP was the primary source of the pollutants. The average deposition rates of Cd, Pb and Zn were 0.33, 1.75, and 30.97 g/m^2 year, respectively at 1 km away after HZP, and 0.0048, 0.035, and 0.20 g/m^2 year, respectively at 10 km away after HZP. There is a risk of secondary pollution to the environment as well as the food chain in seriously polluted areas used for cultivation.

1. Introduction

The accumulation of heavy metals in agricultural soils is of increasing concern due to food safety issues, potential health risks, and the detrimental effects on soil ecosystems [2,7,11]. Air pollution associated with metal smeltery has been increasing in China. The soil surrounding the Zhuzhou Smeltery had a high Cd pollution index, and the nearby paddy fields were primarily polluted with Pb [12]; most lands around the Shenyang Smeltery in Northeast China were found to be heavily polluted with Cd, Pb and Zn, which led to the shut down of Shenyang Smeltery in 2002 [1]. Hrsak et al. [6] evaluated the surroundings of a lead smeltery contamination with Pb, Zn and Cu. However, few studies have demonstrated when the pollution occurred and where it came from.

The excess ^{210}Pb (^{210}Pbex) isotope technique can be used to identify the sources and pathways of soil pollutants, as well as to distinguish the pollution intensities of natural and anthropogenic activity. This method can also be used to quantitatively evaluate the relative contribution and effect of pollutants released by anthropogenic activity on environmental quality [3,5,14,17]. A Pb isotope study was conducted on soil profiles in the Swiss National Park and was found that the deposition intensity was approximately 2.2 g/m^2 in polluted soils [4].

The Huludao Zinc Plant (HZP), which is the largest Zn smeltery in Asia, was constructed in 1937. The smelter recovery rate of non-ferrous metals was maintained at 92.30–95.26% from 1980 to 2005, and the atmospheric recovery rate was less than 27.46% in 1985. A few atmospheric recovery devices were put into use in the 1990s, but the atmospheric recovery rate did not change (Internal Information of the Archives Office of HZP). The major goals of this study were (1) to assess the extent of soil pollution and crop pollution in the surroundings of HZP; (2) to determine the atmospheric deposition rate of Cd, Pb and Zn associated with HZP, and (3) to identify the date of soil pollution and the source of pollutants using the ^{210}Pbex isotopic technique.

2. Materials and methods

2.1. Site description

Huludao Zinc Plant (HZP) is a state enterprise of non-ferrous metal smelter and is the largest Zn smeltery in Asia. It was constructed in 1937 and is located at E120°56′18.2″, N40°43′.8″ (Fig. 1). The annual production capacity of non-ferrous metals was 430,000 tons in 2006, including 330,000 tons of zinc, 600 tons of cadmium, etc. It has 13 smoke stacks higher than 60 m and 6 smoke stacks higher than 100 m. Smoke and dust discharged from HZP contains Cd, Pb and other heavy metals. The discharged particles are eventually deposited in the surrounding soil. According to the statistic data of Environmental Protection Bureau of Liaoning Province (2003),

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