Sources of lead and zinc associated with metal smelting activities in the Trail area, British Columbia, Canada

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The spatial distribution and deposition of lead and zinc emitted from the Trail smelter, British Columbia, Canada, was studied by strategically locating moss bags in the area surrounding the smelter and monitoring the deposition of elements every three months. A combined diffusion/distribution model was applied to estimate the relative contribution of stack-emitted material and material emitted from the secondary sources (e.g., wind-blown dust from ore/slag storage piles, uncovered transportation/trucking of ore, and historical dust). The results indicate that secondary sources are the major contributor of lead and zinc deposited within a short distance from the smelter. Gradually, the stack emissions become the main source of Pb and Zn at greater distances from the smelter. Typical material originating from each source was characterized by SEM/EDX, which indicated a marked difference in their morphology and chemical composition.

Introduction

The prime source of metals in the environment associated with smelting activities is emissions from the main stacks of the smelter, which discharge thermally altered particulates/elements to the atmosphere.1 Secondary sources, indirectly related to the smelting activities also have a significant role in the total contribution of particles/elements to the environment. The secondary sources are wind-blown fugitive dust from ore concentrate/slag storage piles and in-process manipulation of these materials such as uncovered transportation, loading and unloading. Concentrates contain approximately 70% lead or zinc by weight and are not only blown onto soil and plants, but may also be washed away onto the soil and into streams.1

Additionally, the input of metals to the environment can be related to the past activities of the smelter. These materials are also classified as secondary sources since they are not directly related to the present activities of the smelter. The Trail smelter has operated since 1896, and has certainly contributed to the input of metals in this area. Historical dust can be the result of redundant operations (e.g., roasting of metals) or old dust from past high emissions of the smelter.2 These materials are re-suspended within the region and are not considered as new material in the elemental inventory of the system.

The relative contributions of the secondary source materials versus the material currently emitted from the stack are of interest primarily because emissions from these sources can be reduced by applying the appropriate measures. Also, the contribution of material from the secondary sources could cause a problem in evaluating the impact of the recent emissions from the smelters and consequently the mass balance of elements in the system. For instance, dissemination and relocation of the historical dust within the system may result in an overestimation of the environmental impact of recent emissions from the stack of the smelter, which have been significantly reduced by new technology in the smelting process. Hence, the main objective of this study is to identify and evaluate the relative contribution of elements from each source as related to the smelting activities in the Trail area.

Study area

Teck Cominco’s Trail operation is located in the city of Trail, in south central British Columbia (49°06.5'N; 117°42'W) and adjacent to the Columbia River (Fig. 1). The Trail smelter has been in operation since the original smelter was built in 1896 as a copper-gold smelter. Early in the 20th century production quickly expanded to lead and then zinc. At present, Trail operation is a zinc and lead smelting facility equipped with baghouses, electrostatic precipitators and scrubbers for all major stack/discharge sources. The products of the Trail operation include: zinc, lead, silver, gold, cadmium, bismuth, indium, germanium, copper products, and sulfur products as well as fertilizers. Zinc and lead production capacities are approximately at 230,000 tonnes per year and 160,000 tonnes per year, respectively.3

In a mountainous region such as Trail area, the wind speed and direction is strongly influenced by the elevation and topography of the terrain as well as the orientation of major features such as the Columbia River valley and tributary gorges.4 Wind directions are predominantly to the northwest and southeast with the strongest component towards the southeast.5

Methodology

Sample preparation

Moss for this study (Sphagnum fuscum) was collected from remote areas; treated with 0.5 M nitric acid and then rinsed three times with water. The clean moss was then air dried and placed inside the moss bags, which are meshed, plastic bags consisting of four 8 cm × 8 cm size compartments each of which hold 2 g of moss. A moss-monitoring station consists of...