SOLUBILITY OF As AND Sb IN SOILS ENRICHED FROM VARIOUS SOURCES IN LOWER SILESIA, POLAND

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Introduction

Antimony is a trace metalloid that attracts increasing attention in the world literature (Clemente 2013; Filella et al. 2009). It is considered potentially toxic, however the understanding of its toxicity and environmental behaviour is limited. Antimony is often believed to behave similarly to arsenic. It usually occurs in the environment in association with arsenic or with metallic elements. The cases of high Sb concentrations in soils are known from the areas of contemporary or past antimony ore mining and the areas of arsenic mining and processing (Filella et al. 2009; Clemente 2013). Elevated concentrations of Sb were recorded also in soils contaminated by mining and metallurgy of other metals, in particular zinc, lead and copper. Literature reported the presence of high antimony concentrations in soils in the military and sport shooting ranges (Sanderson et al. 2014). The knowledge on occurrence of antimony in Polish soils is very poor. Its enrichment may be expected from the sites of former Sb mining in several sites of Sudetenland, as well as in the areas of the former arsenic ore mining, such as Złoty Stok, extremely polluted with arsenic (Karczewska et al. 2009; 2013). Further, the soils in the vicinities of copper smelters Legnica and Głogów, highly contaminated by smelter emissions, may very likely contain elevated levels of Sb. Soil enrichment may also be expected in military and sport shooting ranges.

The main objective of this study was to determine total concentrations of Sb, and additionally of As, in soils in the areas of their likely occurrence in the environment, as well as to examine their solubility as related to the source of enrichment and soil properties.

Methods

Soil samples were collected from over 150 sites in Lower Silesia, with particular focus on the specific areas listed above, where enhanced concentrations of Sb may be expected. Soils were divided into the groups according to possible source of Sb enrichment. Total concentrations of Sb and As were determined after soil digestion with aqua regia. Soil solutions were acquired from soils incubated at constant moisture for various time (2, 10, 30, and 60 days), and the concentrations and speciation fo Sb and As in soil solutions were determined. The experiment in currently being continued.

Results

Most of soils examined contained very high concentrations of Sb and As (Table 1). Particularly high concentrations of Sb in soils, up to 437 mg/kg were found, as expected, in the vicinities of small historical Sb mines in the Suteden. Soils of former As mining areas, were highly enriched in As, as reported previously (Karczewska et al. 2007; 2013). Most of those soils contained considerable concentrations of Sb, up to 57.4 mg/kg. The amounts of Sb in most of the shooting range soils were also relatively high, particularly in top soil layers. The concentrations of Sb and As in soils depended both on their origin and

on soil properties, mainly pH and organic matter content. The solubility of Sb in the shooting range soils was much higher than that in geochemically enriched soil samples. The highest concentration of Sb in soil solution was 341 μg/L. The amounts of Sb released into solution in a short time of incubation were in shooting range soils assessed as 0.03-0.44% of total soil Sb. The concentrations of Sb and As in soil solutions acquired at 80% of water holding capacity did not tend to change significantly during prolonged soil incubation. Very high, up to 12.9 mg/L, were the concentrations of As in pore water of mine soils in the historically contaminated sites.

Table 1. The ranges of As and Sb concentrations in soils and in soil solutions acquired after 2- and 10-day incubation of moisture soils.

Groups of sites	N	Total concentrations in soils, mg/kg		Concentrations in soil solutions*, μg/L	
		Sb	As	Sb	As
Historical Sb mines – soils and spoils	28	35.1-437	29-2880	34.0-243	1.12-158
As mining sites	42	0.04-57.4	320-45100	3.8-42.7	56-12900
Other historical mines	26	0.05-122	67-143	0.48-102	0.18-3.08
Shooting ranges	27	<0.01-89.6	2.23-9.2	44.1-341	1.15-18.4
Other sites	35	<0.51	0.30-100	Not determined	Not determined

* The data on Sb and As concentrations soil solutions refer to those samples that contained >3.0 mg/kg Sb.

Conclusion

As expected, enhanced concentrations of Sb occur in soils affected by historical ore mining and processing, in particular those where Sb and As were mined. Solubility of both elements in soils is relatively low if considering their shares released from solid phase into soil solutions. Despite this, their concentrations in pore water should raise concern as they may affect soil biota and other organisms. Sb solubility in shooting range soils is particularly high compared to mine soils.

Research should be continued to identify the factors that may accelerate the release of As and Sb from contaminated soils into soil solutions.

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