Arsenic and heavy metal contents in soil percolation and surface waters from the former mining area of Astano (Switzerland), a key to their sorption behaviour

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In the Malcantone valley N of Ponte Tresa, Southern Switzerland (Fig. 1), local till material and overlying soils show high natural background values of several tenths of ppm of As, Pb, Zn and Cd, due to the widespread occurrence of arsenopyrite-sphalerite-galena-carbonate veins. In an area of about 5 km^2 around the former gold mine of Astano, lie several abandoned addits and dump zones which are at the origin of contaminated surface and ground waters. Three different cases exhibiting an As- and heavy metal contamination can be distinguished (Fig. 2 and 3): (1) Natural, undisturbed sites without mining activity, (2) dump zones from mining activity for gold and silver between 1860 and 1950 (mainly at the sites Costa and Bolle, cf. Fig. 5), (3) site of the former ore treatment manufactory of the gold mine at Beredino where a 2 m thick horizon of concentrated ore debris has been found.

Local soil and soil water compositions

The natural soil is usually acid (pH between 4 and 5) due to granitic till material (Fig. 2). The same is true for the soil near the ore treatment manufactory (soil pH of 3), due to the presence of oxidizing massive sulphides. However, the dump zones have soil-pH values close to 8 due to the presence of carbonate minerals (Fig. 3). In response to this and the degree of soil contamination with heavy metals (Bondietti *et al.* 1994), percolation waters collected in free-flow lysimetres and local spring waters from different sites exhibit very contrasting contamination features (Fig. 4). The soil waters of the natural site with low soil-pH and moderate metal contamination and the site of the ore treatment manufactory exhibit high values of dissolved heavy metals, such as Zn, Pb, and Cd, but relatively low total As-contents.

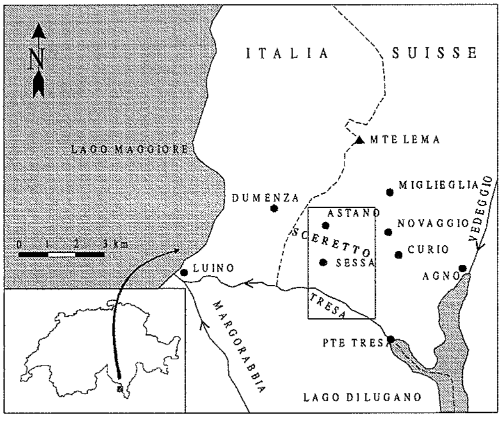

FIG. 1. Location of the studied area in S Switzerland. The frame corresponds with the area shown in Fig. 5.

However, waters from the dump sites with high soil pH have high As-contents, but low heavy metal values. We attribute this to the different sorption behaviour as a function of pH: metals behave as cations which desorb from most materials at low pH,

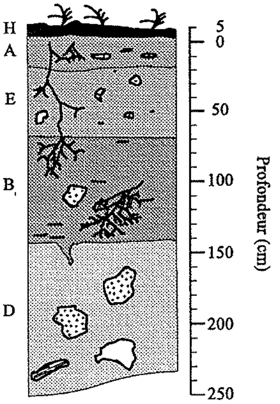

FIG. 2. Typical brown acid soil profile of the undisturbed areas, pH between 4 and 5. H: black humus-rich layer. A: less dark than H, loamy. E: light brown, sandy. Bt: brown-black. D: sandy-loamy horizon, reddish-ochre in colour, interpreted as regional till material.

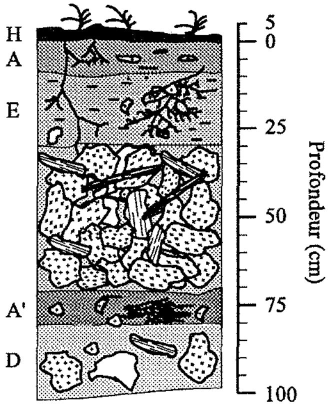

FIG. 3. Typical soil profile of a dump site. The horizons A′ and D obviously represent the natural soil before the mining started and the horizons on top of it represent the dump material covered again by plant debris. H: humus-rich organic horizon. A: clayey still humus-rich. E: oxidized debris horizon of gangue and sulphide material, starting with a light brown sandy horizon. The soil at the former concentration manufactory essentially corresponds with the lower part of the E layer.

whereas the metalloid As shows a typical behaviour of an anion which normally desorb at high pH values (cf. Halter and Pfeifer, 1998). Sequential extraction of heavy metals applied to our samples as described by Keller (1991) indicate that in the natural soil, e.g. for Zn and Ni, 85% are bound to a silicate clay phase, whereas in the dump soil 30–50% are bound to secondary Mn-oxides, 6–20% to Fe-oxi-hydroxides and the remaining to sulphides and organic material (Rey 1996). For As no results are yet available.

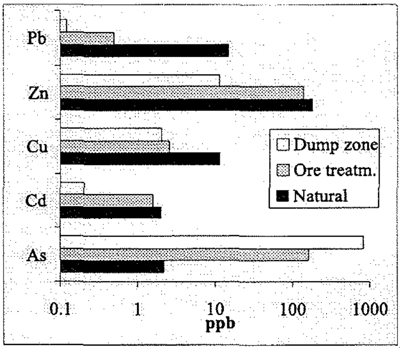

FIG. 4. Typical composition of soil waters from the three different contamination situations.

Regional surface waters

In order to check the environmental impact of the Astano ore deposit and its former mining activity on a regional scale, spring, creek and river waters have been sampled and analysed for As and heavy metals in an area of about 30 km^2 around the mine (Fig. 5). Although the WHO recommends a threshold for As of 10 μg/l for drinking purposes, in Switzerland limiting values are still at 50 μg/l As for drinking and 100 μg/l for waste waters respectively. Spring and creek waters in the former mine area vary between 40 and 840 μg/l As, but decreasing rapidly to below 15 μg/l As downstream. The population of the area drinks local spring water and all springs and wells close to mine area had been analysed for their As-contents during the last 10 years, values between 5 and max. 12 μg/l As. However recent analyses of the main spring used to provide drinking water for the village of Astano, located several km from the mine area, in an apparently homogenous zone of granitic gneisses, revealed As-contents of up to 80 μg/l (Fig. 5, analysis done by the state chemistry laboratory Ticino). We expect that the local till material could be at the origin of these findings (which is however usually acid) or, however less likely, that there is a yet not discovered ore body in the small aquifer of this spring.

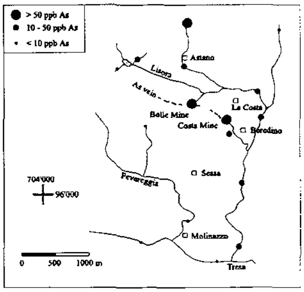

FIG. 5. Arsenic contents in surface waters of the Astano region.

References

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