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Environmental Contamination and Toxicology

Mining Area Environmental Mercury Assessment Using *Abies alba*

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Several Hg biomonitors are used for environmental mercury assessment in mining areas. Among these, lichens are those most studied (Bargagli et al. 1986; Bargagli et al. 1987; Bargagli and Barghigiani 1991) but other vegetal organisms are also employed, such as brooms (Barghigiani and Bargagli 1987), pine needles (Bargagli et al. 1986; Barghigiani and Bargagli 1987) and many other species (Huckabee et al. 1983; Bombace et al. 1973).

This paper reports the results of a mercury assessment at Mt. Amiata (Italy) based on the metal concentration in needles of *Abies alba*.
Mt. Amiata is an area of Tuscany characterized by the presence of cinnabar deposits. The mercury extraction activity was ended in 1975, but the environment is still contaminated by the metal.
Abies alba is a widespread conifer tree in Italy whose needles live about fourteen years. It is present not only in the woods but also in many parks and gardens.

MATERIALS AND METHODS

Three sampling stations were chosen in the Mt. Amiata area (Fig. 1). Station A was located on the northern side of the area, about 7 km from the mine of Abbadia San Salvatore. Station B was located at about 1500 m elevation, 3 km from the same mine. Station C was located at Abbadia San Salvatore near a vast spoil bank of roasted cinnabar which was reforested about 18 years ago.
A pool of 5 g of needles of each age (from 1 to 13 years) was collected from three trees at each station, together with 5 samples of surface and deep soil.
Pools of 2 g of bark were also collected from the branches to which the sampled needles were attached.
In the laboratory, the bark was carefully stripped from branch and root samples, and impurities such as plant residues and gravels were removed from soil.

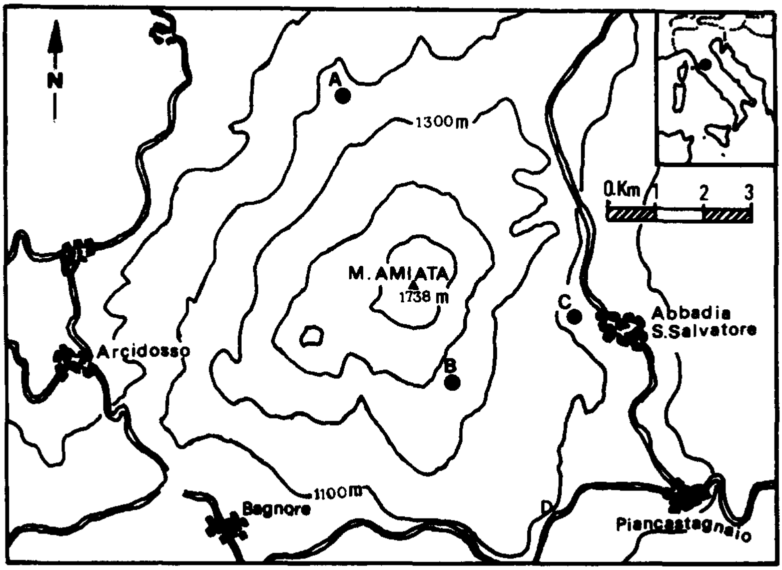

Figure 1. Mt. Amiata area. Locations of the sampling stations.

Of each sample 0.5 g was digested with HNO_3 in a pressurized decomposition system at 120°C for 6 hours and analysed for Hg by cold vapor atomic absorption spectrophotometry (AAS).
The dry weight was determined on subsamples, bringing them to constant weight at 60°C in an oven.
The analytical procedures were tested using Standard Reference Material 1572 (citrus leaves, Hg content 0.08±0.02 ppm) of the National Bureau of Standards (U.S.A.).
At each station 3 measurements of atmospheric Hg were performed. The air mercury was sampled by amalgamation of Hg on gold traps connected to battery-driven pumps. The traps consisted of a gold sheet (10mm x 30mm x 0.07mm), spiralized and inserted in a quartz tube (3mm internal diameter). The pumps had an average flow of 0.5±o.2 l min^{-1}. Mercury measurements were performed by AAS on the metal thermally released from the gold amalgam. The procedure have been described in greater detail elsewhere (Barghigiani et al 1990).

RESULTS AND DISCUSSION

The results on mercury content in needles and bark at the different stations are reported in Fig. 2.
At station A the relationship between Hg concentration and age was not significant in needles (Fig. 2A). The reverse relation between Hg content in bark and age was due to the inexplycably high Hg levels present in the samples of the first four years.

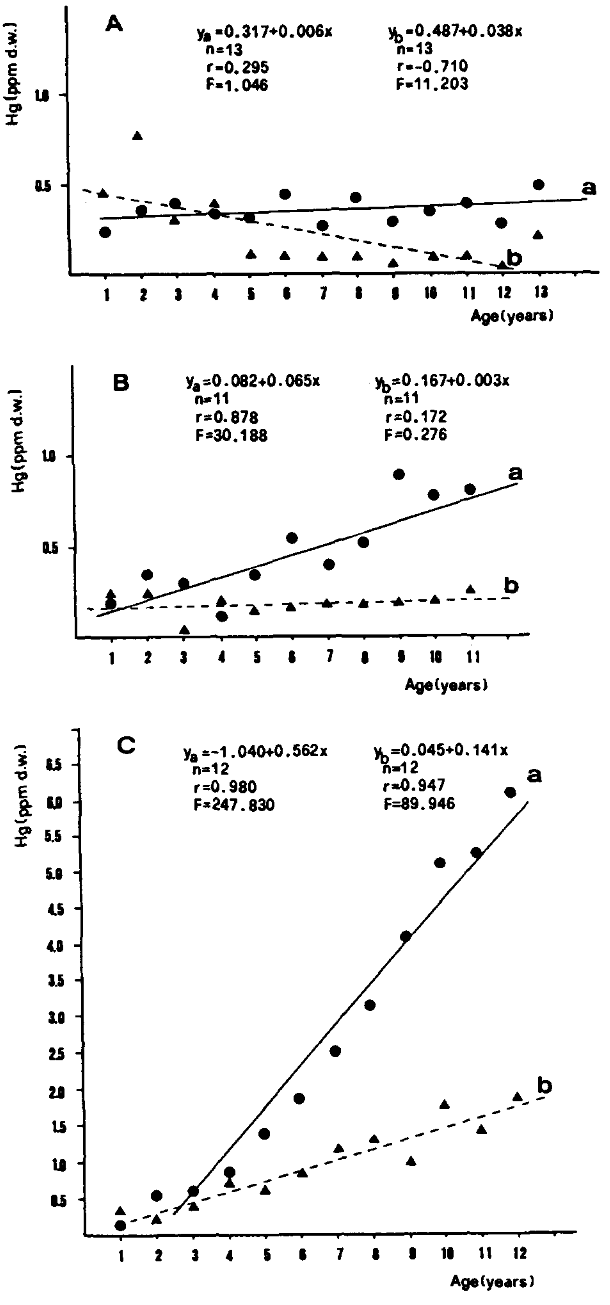

Figure 2. Hg concentration versus age (ppm d.w.) in *Abies alba* needles (●) and in bark of branches to which they were attached (▲). A: station A; B: station B; C: station C.

At station B the metal concentration increased with age in needles, while it did not increase for bark (Fig. 2B).
Figure 2C shows that at station C the relation between mercury concentration and age was significant both in needles and in bark.
From comparison among the three stations it appears that the different environmental mercury contamination was evident only from Hg analyses of needles of 4-5 years of age on up.
The much higher Hg contamination at station C than at A is in agreement with previous data on *Pinus nigra* and *Cytisus scoparius*, a broom which is widespread on Mt. Amiata (Barghigiani and Bargagli 1987). As regards station B, no previous datum was available for comparison.

The results of mercury measurements in bark were less indicative for the evaluation of the environmental mercury impact. Indeed, for bark, significantly higher concentrations of the metal were observed at station C only.

Table 1. Hg concentrations in 11 year old needles and soil ($\mu g\ g^{-1}$ dry weight), and in the air ($ng\ m^{-3}$). Average values ±S.D. are given. For soil and needles, n=5; for air, n=3.

Station	A	B	C
Abies alba	0.40 ±0.17	0.80 ±0.29	5.23 ±1.92
Soil surface	0.81 ±0.25	1.01 ±0.30	85.20 ±18.0
deep	0.25 ±0.08	0.34 ±0.11	5.75 ±1.05
Air	8.8 ±3.4	5.4 ±1.2	21.92 ±4.12

From Table 1 it appears that the concentrations of the 11 year old needles reflect those both of surface and deep soil. The relation between Hg contents in needles and in air is less evident. Indeed, evaluating the environmental Hg impact by direct measurements of air mercury levels is a real problem due to the extreme diurnal and seasonal variability of the atmospheric metal concentration (Breder and Flucth 1984; Ferrara et al 1986). That the reason why Hg biomonitors are very important for the assessment of the environmental contamination of this metal (Bargagli and Barghigiani 1991; Barghigiani et al 1991).

It must be pointed out that mercury is phytotoxic (Siegel and Siegel 1979) but at no studied station did the fir trees display evident toxic manifestations. From the results of this work it appears that *Abies alba* is a good biomonitor of mercury contamination and that its needles are particularly suitable for this purpose. Furthermore, for comparison between areas with different environmental Hg contamination, it is appropriate to analyse needles of different ages and to consider the mercury concentration trend.

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