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Survey of Barium in Italian Drinking Water Supplies

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Trace metal contamination in public water supplies may be detrimental to human health. In recent years there has been increasing attention paid to the presence of barium in public water supplies and to its possible effects on human health (Kojola et al. 1978, Subramanian and Meranger 1984). Recently the maximum allowed level for barium in drinking water in Europe has been reduced from 1 mg/L to 0.1 mg/L (Council Directive 80/778/EEC). Even if little is known about the geochemical origin of barium, it is likely that it may represent the major source in drinking water supplies. It is possible, however, that industrial sources may significantly affect barium levels in drinking water supplies. If this is so, it should be reflected by different barium levels in surface or groundwater, with consequently different exposures and risks for the population.

The toxic effects following acute ingestion of soluble barium salts are well characterized (Goodman and Gilman 1970, Roza and Berman 1971). The cardiac electrophysiological effects of barium have been the object of many experimental studies (see Delfino et al. 1988 for references). However, little is known about toxicity due to long-term exposure to barium (Kojola et al. 1978). Elevated barium levels (2.0-10.0 mg/L) in drinking water have been associated with higher mortality rates due to cardiovascular or heart diseases (Brenniman et al. 1979). Experimental (Kopp et al. 1985), but not epidemiological studies (Brenniman et al. 1981) suggest a correlation between levels of barium in drinking water and high blood pressure.

The present survey was undertaken to evaluate the extent of exposure of the Tuscany population to barium. Levels of barium were measured in drinking water supplies, represented by bottled (usually marketed

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without barium determination) and municipal waters (groundwater and treated water).

MATERIALS AND METHODS

191 drinking water supplies were selected: 60 different brands of bottled drinking water (bottled waters), 92 municipal groundwaters (groundwaters), 39 municipal surface waters supplies (treated waters).
Bottled waters were chosen from among the national mineral waters most sold in Tuscan supermarkets. Municipal waters were selected in Tuscany, and surface water samples were taken from the Arno river at the point where potable water emerges from the treatment plants.
The water samples were collected in the daytime from January 1987 to April 1988 using a polyethylene bottle. Barium was determined using graphite furnace atomic absorption spectrometry. The accuracy, precision data, and the merits of analytical procedure have been recently reported (Fagioli et al. 1988). In brief, measurements were made with Perkin-Elmer Model 5000 Atomic Absorption Spectrometer equipped with an HGA 400 graphite furnace, a tungsten iodide background corrector and a Model 050 strip-chart recorder. An AS-40 autosampler was used for automated operation and an Intensitron barium hollow-cathode lamp was employed. All the measurement were carried out with normal graphite tubes. In order to prepare intermediate reference solutions of various concentrations, a stock solution of barium (1000 mg/L, BDH) was diluted with deionized water using Gilson micropipettes of the Pipetman P series.

RESULTS AND DISCUSSION

Fig.1 shows the single and median values with the interquartile range for barium in bottled water, groundwater and treated water. It is apparent that a great variability is present in bottled waters (range 7-660 µg/L) and groundwaters (range 7-1160 µg/L) while the barium concentrations are quite homogeneous in treated waters (range 13-140 µg/L). The median value for groundwater is higher than the maximum allowed concentration according to the EEC guidelines.
On the whole 95 out of 191 samples (49.7%) have barium concentrations lower than 100 µg/L. In detail, 60% of bottled water, 53.8% of treated water and 41.3% of groundwater samples have barium levels lower than 100 µg/L (Table 1). 18.3% of bottled water have barium levels below the detection limit (CL) of 7 µg/L.
The levels of barium were not significantly altered during water potabilization. The values of barium remained practically unchanged in the raw (Ba levels

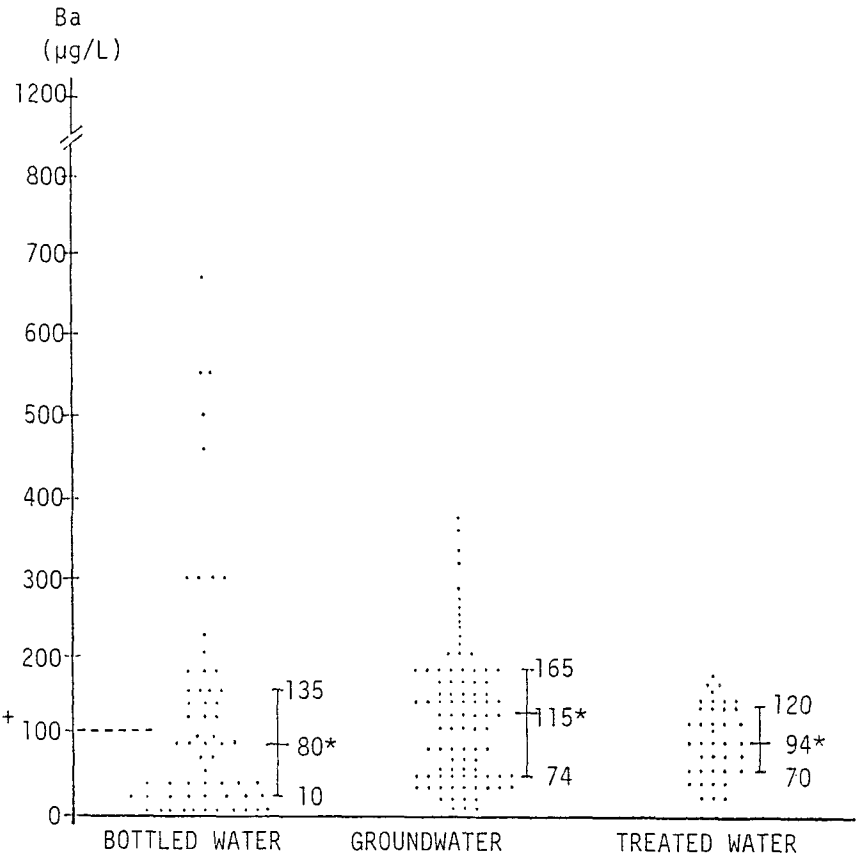

Figure 1. Barium concentration in 191 Italian drinking water supplies
* Median and interquartile range
\+ EEC guideline

ranged from 7-250 µg/L in 39 samples) and treated water. The values were not significally different in different seasons. These findings suggest that the presence of barium in the Arno river (no matter if of geochemical or industrial origin) is constant and fortunately quite low, and that the procedures used in the potabilitation plants are ineffective in lowering barium levels.

A few samples of groundwaters and bottled waters present high barium levels, possibly as a consequence of the geochemical environment, which is presumably the primary determinant of barium levels in groundwater.

On the whole, the levels of barium in the Italian drinking water supplies are superimposable to those recently found in Canadian drinking water supplies (Subramanian and Meranger 1984). In Canada (as in the

Table 1. Frequency of barium concentration range in 191 different samples of Italian drinking water supplies.
* EEC guideline

Ba	bottled water		groundwater		treated water	
(µg/L)	No samples	cumulative %	No samples	cumulative %	No samples	cumulative %
<CL	11	18.3	3	3.3	0	0
7-99	25	60.0	35	41.3	21	53.8
*						
100-199	13	81.7	37	81.5	18	100.0
200-299	2	85.0	11	93.4	0	100.0
300-399	4	91.6	4	97.8	0	100.0
400-499	1	93.3	0	97.8	0	100.0
500-599	3	98.3	0	97.8	0	100.0
>599	1	100.0	2	100.0	0	100.0
total	60		92		39	

USA) however, the maximum acceptable concentration value for barium is 1 mg/L (Guidelines for Canadian Drinking Water Quality, 1979).
It appears that barium drinking water standards have been developed in the absence of studies examining the human health effects associated with drinking water intake.
The reduction of the barium standard in drinking water in Italy (EEC Guidelines) to 100 µg/L appears consequently to be based on questionable criteria and implies that 50.3% (96/191) of the Italian drinking water supplies are not within the confines of the directive.

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