Spatial Variability and Concentration of Arsenic in the Groundwater of a Region in Southwest Buenos Aires Province, Argentina

by

Juan D. Paoloni, Carmen E. Fiorentino, Mario E. Sequeira, and Nora Echeverría

Juan D. Paoloni is chair of hydrology and irrigation in the Department of Agronomy at the Universidad Nacional del Sur and CONICET, Bahía Blanca, Argentina. Carmen E. Fiorentino is chair of hydrology and irrigation in the Department of Agronomy at the Universidad Nacional del Sur at Bahía Blanca, Argentina. Mario E. Sequeira is with the Center for Renewable Natural Resources of the Semi-Arid Zone (CONICET) and chair of agricultural hydraulics and hydrology in the Department of Engineering, Universidad Nacional del Sur, Bahia Blanca, Argentina. Nora Echeverría is chair of soil conservation and management in the Department of Agronomy, Universidad Nacional del Sur, Bahía Blanca, Argentina.

Arsenic is widely found in the natural environment mainly as an outcome of processes related to vulcanicity but also as a consequence of anthropogenic use of inorganic forms such as arsenate and arsenite (Varillas et al. 1997). Material of volcanic origin is transported in suspension in the atmosphere and deposited as lenticular layers in the sediment on plains (Bolzicco et al. 1997). These layers undergo a washing process and the resulting fragments are subsequently mobilized by means of various infiltration and straining mechanisms, ending up in surface and groundwater (Bhumbla and Keefer 1994).

Chronic endemic hydro-arsenism is caused by the consumption, over prolonged periods, of water containing higher than normal concentrations of arsenic (Biagini et al. 1995). It is estimated that some 30 μg of arsenic per kilo of body weight is incorporated into the human organism daily, solely on the basis of the average arsenic content in food (Formigli et al. 1997). The World Health Organization (WHO) (1995) estimated that the average daily intake of inorganic arsenic from water reaches similar levels to that ingested via foodstuffs. This serious public health hazard is known to exist in Argentina (Salvador 1987) and was already recognized early this century (Ayerza 1918).

The ingestion of water highly contaminated by arsenic is still quite common in Argentina, particularly among rural and suburban populations (Trelles et al. 1970), where the pathology is frequently diagnosed. Numerous cases have been recorded in the east and southeast of the Mediterranean province of Córdoba (Tello 1951), where, given the geographical distribution of the detected cases, the pathology has acquired a regional character. Arsenic has also been detected in the soils and waters of northwestern Buenos Aires Province, northern San Luis, southern Santa Fé (Aribére et al. 1997), southern Chaco, eastern Santiago del Estero, and eastern La Pampa Province (Bolzicco et al. 1997).

The goal of this study was to determine the presence, distribution, and concentration of excessive quantities of arsenic in the groundwater of an extensive region in the south of the province of Buenos Aires. We take as reference the drinking water criteria laid down by the FCUDW (1994) and the WHO (1995). The risk level in drinking water for cattle and the maximum advisable risk tolerance level for irrigation water in accordance with the guidelines laid down by FAO (Ayers and Westcot 1987) are also considered. A map has been drawn up outlining the areas most at risk and the spatial variability of arsenic concentrations to serve as a basis for implementing preventive medicine for

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humans and animals and with a view to controlling the pathology. The data regarding the maximum advisable levels of arsenic in irrigation water have implications for the agrifood sector.

Materials and Methods

The study area comprises the zone of influence falling within a radius of approximately 200 km around the city of Bahía Blanca in the province of Buenos Aires, Argentina. Maps have been drawn up on the basis of those published by the Instituto Geográfico Militar and cover a semicircle of approximately 64,670 km2, leaving out one sector south of the Colorado River that is less densely populated than the rest of the area (Figure 1).

Selective and specific sampling was performed on groundwater used for different consumption purposes, in particular, the more easily accessible phreatic waters where sufficient discharge to meet supply requirements can be achieved through the use of simple pumps or low capacity centrifuges.

Hydrochemical analyses were carried out in the laboratory using the electrometer method with a selective electrode and the Arsenic Test technique. Routine laboratory determinations were also performed. The data obtained was used to draw a map of isolines corresponding to the variations in arsenic concentration values and their spatial distribution. Finally, the total area was classified into three categories in accordance with the maximum tolerance levels proposed by the FCUDW (1994) and the WHO (1995).

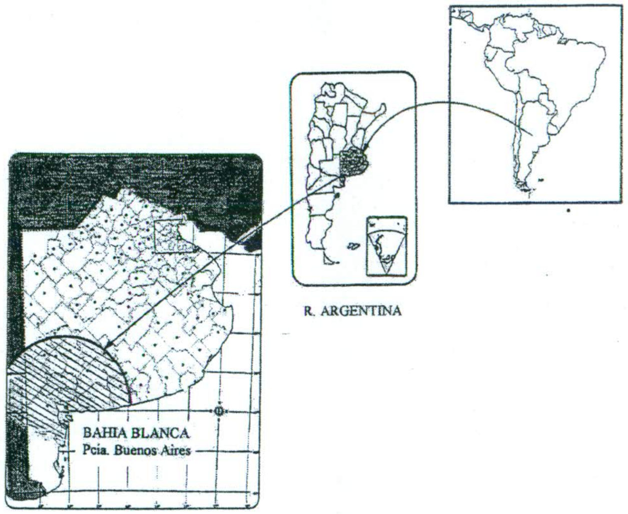

Figure 1. Location map.

Results

The data obtained from the selective sampling and qualitative analysis of groundwater was incorporated into the Figure 2 map in the form of isolines representing the spatial variability of arsenic concentrations (Kieffeer and Bevilacqua 1997; Bolzicco et al. 1997).

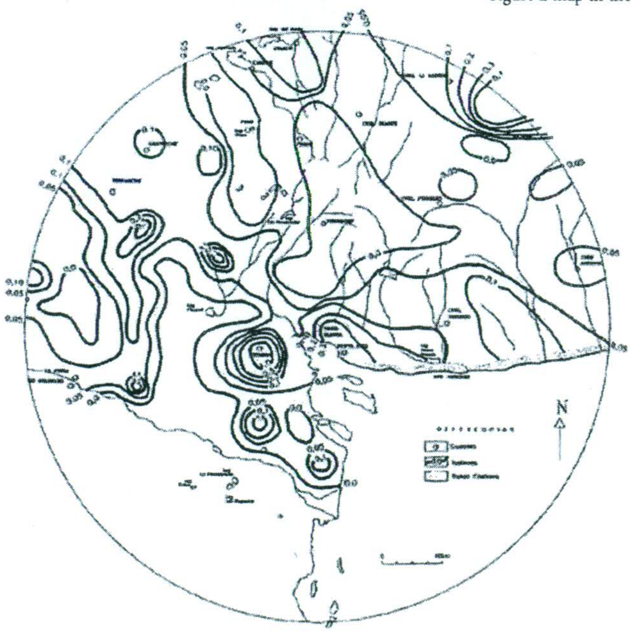

Figure 2. Distribution of isoline indicating arsenic concentration.

Table 1. Water classification according to concentrations and areal coverage.

	km^2	%
Water with no As	14,870	23.0
Water with up to 0.05 mg L^{-1} As	24,500	37.9
Water with more than 0.05 mg L^{-1} As	25,300	39.1

Taking as reference point the maximum tolerance level of 0.05 mg L^{-1} laid down by the FCUDW and the WHO for this carcinogenic chemical substance, water was classified in terms of the concentrations found and areal coverage.

Figure 2 shows the pattern of arsenic concentration is highly irregular. A wide range of values was recorded within the most affected zone, representing 39.1% of the total area, in some cases reaching up to 0.30 and 0.40 mg L^{-1}, even 1.0 mg L^{-1} in the area corresponding to the town of Médanos.

At the other extreme, 23.0% of the study area was found to be completely free of arsenic, commencing a few kilometers to the north of the city of Bahía Blanca and including the localities of Tornquist, Pigüe, and Sierra de la Ventana. This region coincides almost exactly with the mountain range of the orographic system of Ventanía, and the excellent quality of the surface drainage water and groundwater here constitutes a valuable asset for the development of the tourist industry in the area.

The accepted upper limit for arsenic in water consumed by cattle is considered to be 0.20 mg L^{-1} (National Academy of Sciences 1972, 1974), though even this level can lead to chronic intoxication (Bavera et al. 1999), especially when the water is consumed over prolonged periods. The highest concentrations of arsenic in drinking water for cattle were recorded in a small sector to the southeast of General La Madrid and some zones to the west, southwest, and south of the city of Bahía Blanca where livestock production is the predominant economic activity.

For agricultural purposes, the maximum advisable concentration of arsenic in irrigation water varies from crop to crop, ranging from 0.05 mg L^{-1} for Oryza sativa (rice) to 12 mg L^{-1} for Sorghum sudanense sudangrass (Ayers and Westcot 1987).

Conclusion

In over a third of the study area, the water is of restricted suitability for human consumption, especially when taking into account that low doses are ingested over prolonged periods. The same criterion is valid for livestock drinking water.

The map drawn up on the basis of the experimental data determines zones with different arsenic concentrations, making it possible to identify high risk areas with a view to evaluating the public health consequences for the human population and the effect on agricultural and livestock production.

The preliminary evaluations presented here provide the necessary background information for the relevant local health authorities to be able to implement preventive measures, thus assuring a positive impact on the health of the local population in the affected zones.

Given that the study area comprises a high potential region for socioeconomic development, it is recommended that the findings of the present study be used in the rational planning of water supplies for human and cattle consumption, as well as irrigation.

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