SPATIAL PREDICTION OF ARSENIC OCCURRENCES IN GROUNDWATER IN THE SANTA ROSA BASIN, CATAMARCA, ARGENTINA

Morvillo, Mónica [1] ; Battistella, Romina [2]; Ortega, Irene [2]

(1) Facultad de Ciencias Exactas, Físicas y Naturales-Universidad Nacional de San Juan. Argentina

(2) Instituto Nacional del Agua-Centro Regional de Aguas Subterráneas- San Juan. Argentina

ABSTRACT

This paper presents a predictive map of arsenic values in groundwater in the Santa Rosa Basin, to serve as a tool for planning and reducing health risk in the local population. The prediction is based on water well sampling conducted during 2014, in 72 wells with depths of less than 250 meters. For spatial interpolation, Kriging was applied. Kriging is a geostatistical technique that allows the representation of distinctive aspects of spatial variability, such as the tendency of the arsenic occurrences in the region and the autocorrelation at different spacing scales and directions of anisotropy.

LOCATION AND BACKGROUND

South America has one of the largest extensions in the world affected by a naturally-occurring arsenic problem (Figure 1) . Most studies relate it to quaternary vulcanism and the associated hydrothermal activity of the Central Volcanic Zone of the Cordillera de los Andes, between the 14° and 28° South latitude, generated by more than fifty volcanoes, some of them still in activity.

The study area corresponds to the Santa Rosa Basin, between 27° 51' and 28° 16' South latitude and 65° 06' and 65° 33' of West longitude, in the Province of Catamarca in Argentina (Figure 2).

The data analyzed was provided by the Instituto Nacional del Agua - Centro Regional de Agua Subterránea, based on a "Hydrogeological Study of the Santa Rosa and Aconquija Basins", in agreement with the provincial government to determine the availability of the underground water resources and potentially potable areas.

In that context, during 2014, 72 groundwater samples were taken corresponding from 66 wells with an average depth of 180m and from 6 excavated wells, which pump permeable horizons between 10 and 323 meter depths.

On Figure 2, the sampling wells are located, highlighting in red color those whose arsenic concentrations exceed the limit threshold value of 0.01 mg / L.

Figure 1

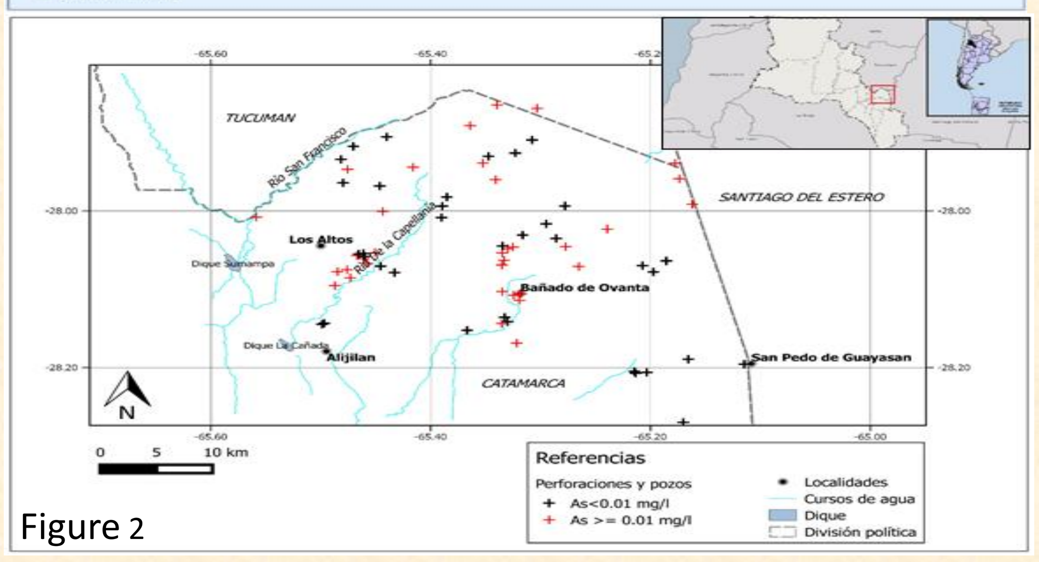

Figure 2

PREDICTION and CONCLUTION

METHODOLOGY- KRIGING

For the interpolation in new sites from a set of observed values, $v(s_1)\ldots v(s_n)$, the kriging technique is applied. $V_k(S)$, which generates contour maps, based on the geostatistical structural model that synthesizes the spatial properties of the variable: **μ** (***s***) the spatial trend of variable throughout the study region, with a deterministic component, parameterized with polynomials (of degree 0, 1 or 2) as a function of the coordinates of ***s*** and **δ** (***s***) which is the stochastic component around the trend, parameterized with the semivariogram function **γ.**

Kriging $$V_k(s) = \lambda_1 v(s_1) + \cdots + \lambda_n v(s_n)$$

Structural Model Semivariogram

$$\boldsymbol{V(s)} = \mu(\boldsymbol{s}) + \boldsymbol{\delta(s)}$$

$$\boldsymbol{g(h)} = \frac{1}{2}\boldsymbol{Var[\delta(s+h) - \delta(s)]}$$

STRUCTURAL ANALYSIS

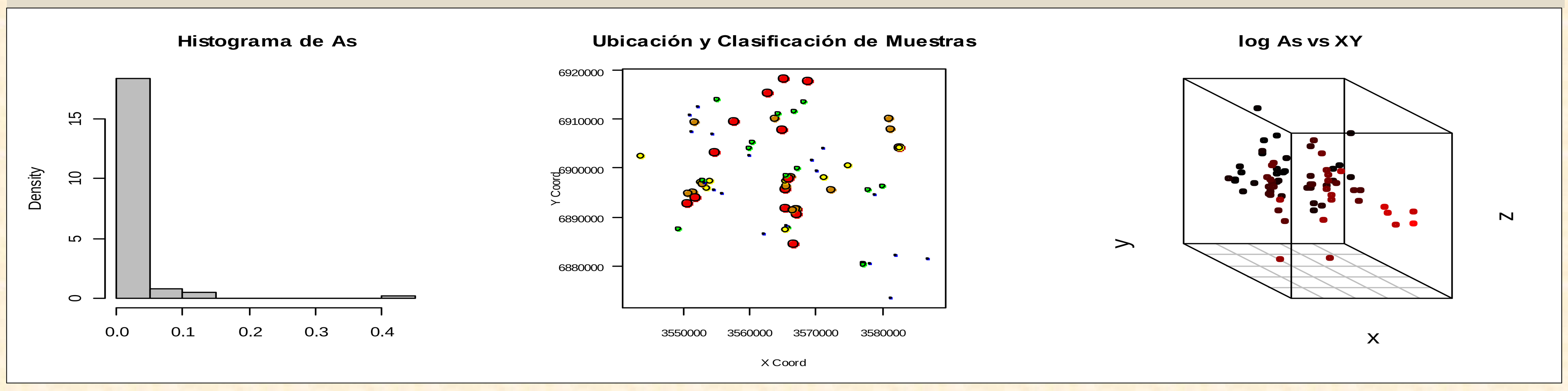

Figure 3: From left to right: a) Histogram of arsenic; b) Location of groundwater samples classified into five categories according to their arsenic concentrations; c) Diagram of dispersion of the concentrations of arsenic (log scale) as a function of the coordinates.

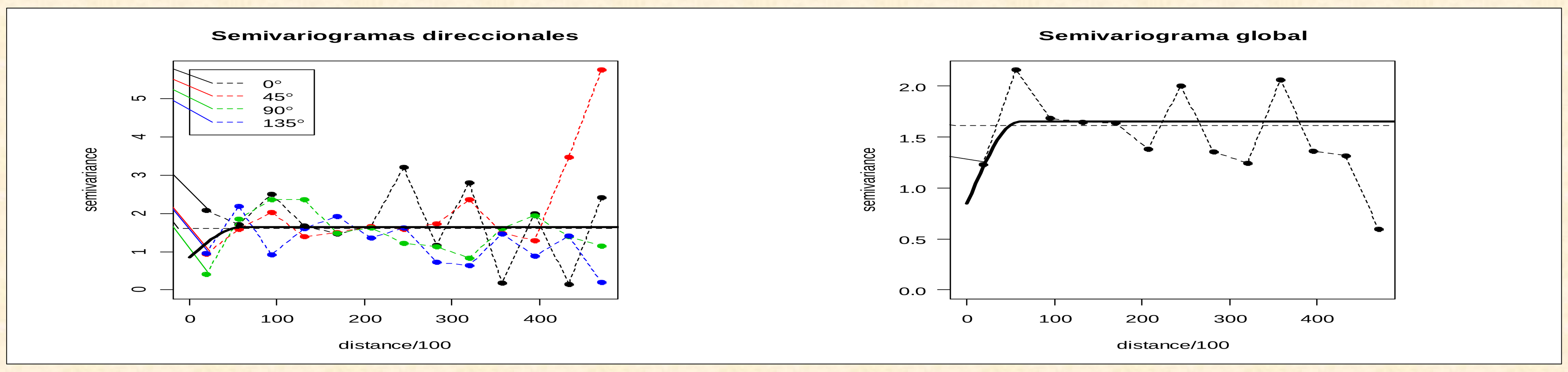

Figure 4: The dotted lines of the graphs correspond to the directional (0°, 45°, 90°, 135°) and global semi variograms respectively. The continuous line corresponds to the theoretical spherical semi variogram assumed for the structural model.

RESULTING CONTOUR PLOT FOR ARSENIC

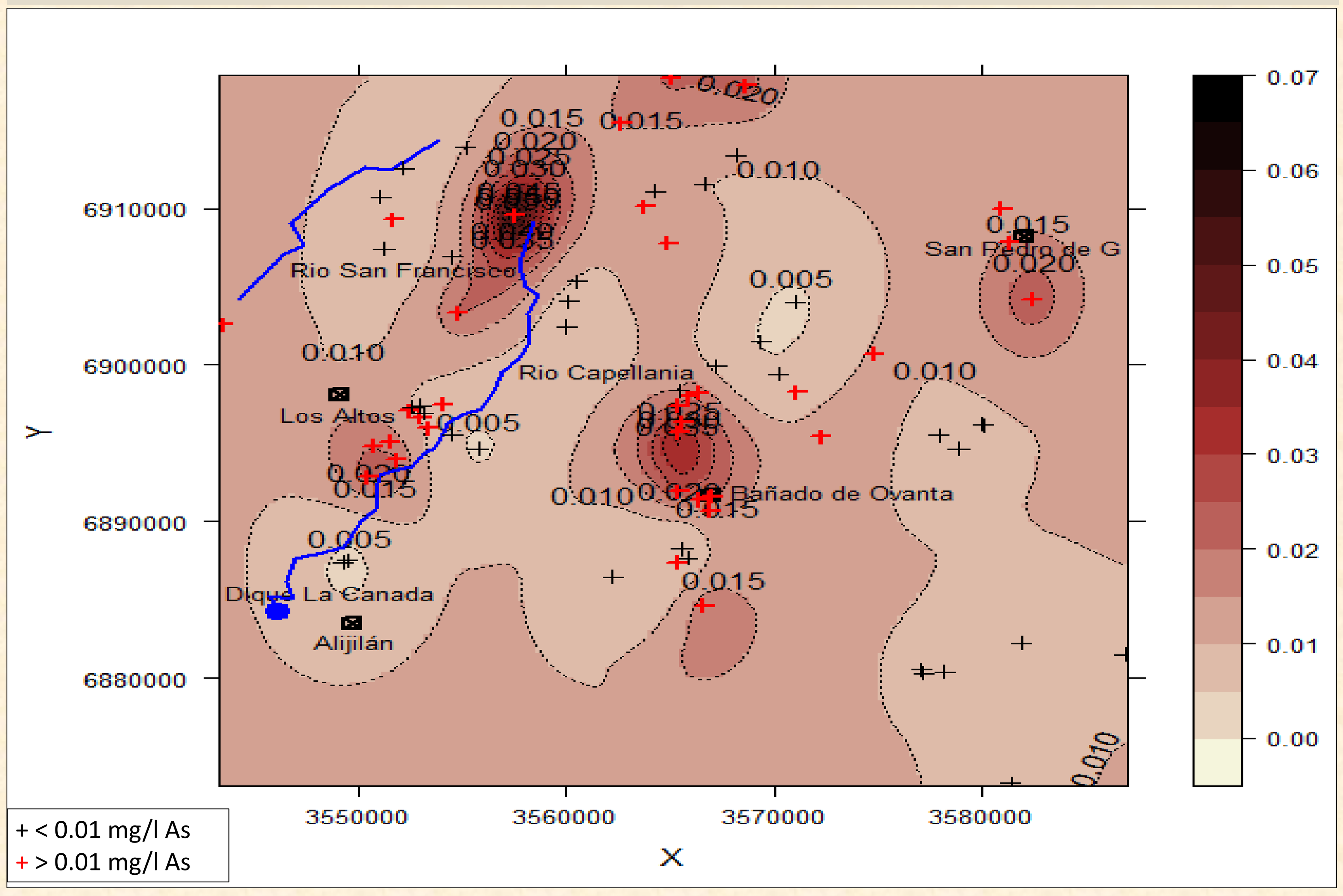

Figure 5: Predictive map for arsenic in the study region.

The predictive map shows an average value higher than 0.01 mg / l Arsenic, being the limit for the WHO (World Health Organization), nevertheless the CAA (Codigo Alimentario Argentino) establishes 0.05 mg / l. However, the study of the subterranean water resource indicates that there are active perforations with high arsenic concentrations in areas where rural and urban inhabitants carry out activities of different types. Management options to avoid the risk of contaminated water consumption are: supply of alternative water sources without arsenic, treatment through optimized water treatment plants, demineralising tecnologies, bioremediation