Hydrochemical characterization of groundwater in the Guadalquivir River aquifer in western Jaén: application of geostatistical techniques

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INTRODUCTION

The alluvial aquifer of the Alto Guadalquivir River is a shallow aquifer located in the central part of the province of Jaén, Spain, and its groundwater resources are used mainly for irrigation of crops in an important agriculture-dominated area (Lorite & Jiménez-Espinosa, 2008). This study is located in the western zone of this aquifer (Fig. 1). Hydrochemical and water quality data were obtained from April to June 2003, and 110 water samples were collected. The chemical composition of the water is not only influenced by the agricultural practices, but also by the interaction with the alluvial sediments. A multivariate statistical treatment was carried out, allowing a reduction in the variability of the system and giving three factor variables that synthesize the original information. Furthermore, a geostatistical study of these variables was carried out. In this regard, we calculated variograms of the factorial variables, which form the basis for geostatistical estimation through ordinary kriging. The result of this step allowed a probabilistic representation to be obtained through the mapping of these variables (Fig. 2), assessing the spatial variation of the main physical-chemical processes involved in the quality of the groundwater in this aquifer.

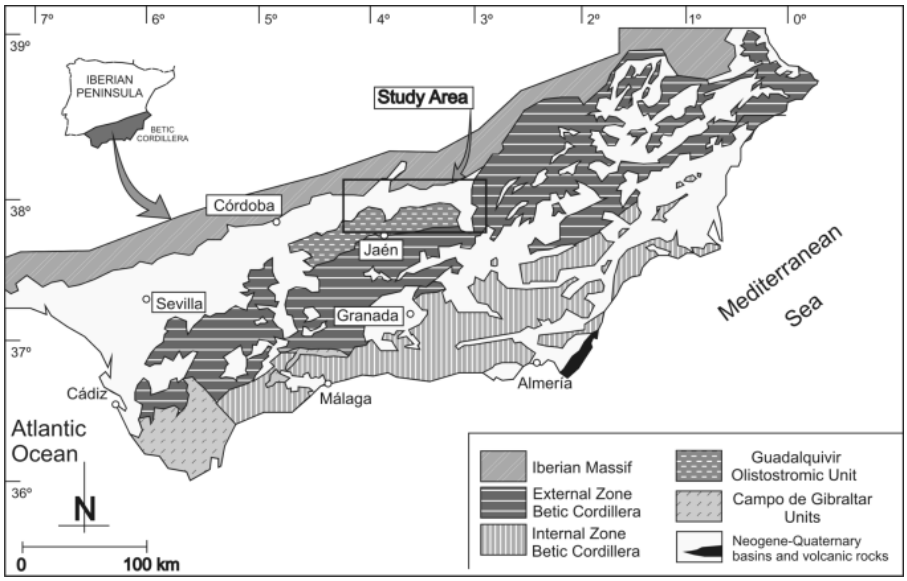

Fig. 1 Geographical and geological location of the study area.

RESULTS AND CONCLUSIONS

The statistical study shows a high correlation between SO_4^{2-}, Cl^-, Na^+, Ca^{2+}, Mg^{2+} and the conductivity, represented by PC1. This association suggests that the mineralization is related to local geology. The boundaries of the aquifer are Miocene marls. Triassic olistholiths of the

Guadalquivir basin (marls, clays and gypsum) are mixed with these materials. A high correlation between the ions Cl^- and Na^+ is observed by numerical analysis. Their concentration is associated with lithologies in the zone. In the formations situated in the surrounding area of the alluvial aquifer, especially in the southern sector, interbedded halite (NaCl) levels associated with levels of gypsum are found. The second component of the statistical analysis was associated with the ions NH_4^+, K^+ and HCO_3 and P. Negatively correlated with the above were the NO_3^- and pH. However, the third factor includes piezometric level and concentration of NO_3^-. The interpretation of these two components suggests that the spatial distribution of these ions is conditioned by agricultural practices. The use of agricultural fertilizers causes accumulation in cultivated soil of many nutrients that can be washed out by rainwater or irrigation and swept into the saturated zone. There is a negative correlation between NO_3^- and K^+, and P. This reveals two different agricultural practices: (1) a subscriber applied potassium and phosphorus is only localized in some sectors of the area; and (2) a nitrogenous fertilizer, which has emerged as the most common fertilizer used in the study area. In relation to nitrate, PC3 shows that high concentrations occur diffusely throughout the area, which involves the extensive use of this type of fertilizer and the presence of oil mills.

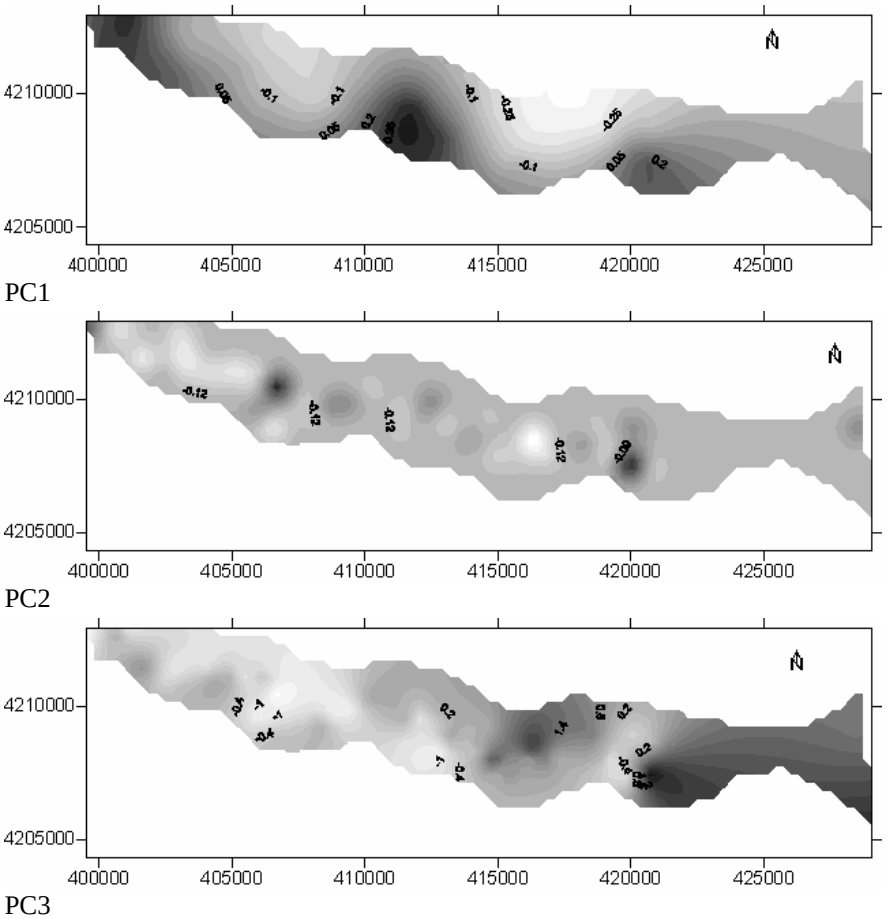

Fig. 2 Ordinary kriging maps of PC1, PC2 and PC3.

REFERENCES

Lorite, M. & Jiménez-Espinosa, R. (2008) Impact of agricultural activity and geologic controls on groundwater quality of the alluvial aquifer of the Guadalquivir River (province of Jaén, Spain): a case study. *Environ. Geol.* **54**(7), 1391–1402.