



## **Integrating Multivariate Statistical Analysis and GIS for the delineation of the hydrochemical processes of two aquifers in Nomia, Monemvasia Municipality, Greece**

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In the wider area of Nomia (Monemvasia Municipality) two main aquifers are being developed. The underlying one (deep aquifer) occurs in fractured hard rocks (Phyllites – Quartzites unit) and is subjected to intense exploitation by deep boreholes, both for municipal water supply and extensive group irrigation needs. The overlying aquifer (shallow) forms in porous, post-alpine formations and covers limited individual irrigation needs, mainly by wells.

Fourteen hydrochemical parameters were considered ( $\text{pH}$ ,  $\text{E.C.}$ ,  $\text{Ca}^{+2}$ ,  $\text{Mg}^{+2}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ,  $\text{NO}_3^-$ ,  $\text{SO}_4^{-2}$ ,  $\text{HCO}_3^-$ ,  $\text{PO}_4^{-3}$ ,  $\text{SiO}_2$ , total Fe,  $\text{Mn}^{+2}$ ) in fifty five samples collected from both aquifers (fifteen from the fractured hard rocks aquifer and forty from the porous one) during May 2004. The interpretation of the hydrochemical results with the trilinear diagram (Piper) showed that the dominant water-type for both aquifers is  $\text{Ca}^{+2}\text{-Mg}^{+2}\text{-HCO}_3^-$ .

Multivariate statistical analysis was performed using Statistical Package for Social Sciences (SPSS version 23.0) separately for each aquifer, in order to examine the importance of each parameter, investigate correlations among them, separate them into groups and finally delineate the hydrochemical processes of the aforementioned aquifers.

Application of the R-type factor analysis concluded with the selection of five factors for the samples coming from the deep aquifer and in six factors for the samples coming from the swallow aquifer, which explained 88.1% and 90.6% of the total variance respectively. Once statistical factors for both aquifers were selected, their geographical distribution was also mapped using GIS.

The first factor of the fractured hard rocks' aquifer amounts for 44.14% of the total variance of the database, outlining interactions of groundwater with the weathering products of metamorphic rocks, since high loadings were exhibited for  $\text{Na}^+$  (0.89),  $\text{Cl}^-$  (0.68) and  $\text{SiO}_2$  (0.94).

As far as the porous aquifer is concerned, the first factor amounts for 46.19% of the total variance of the database, while the dominant interactions are salinity and hardness, since it exhibits high loadings on  $\text{E.C.}$  (0.98),  $\text{Ca}^{+2}$  (0.71),  $\text{Mg}^{+2}$  (0.91),  $\text{Na}^+$  (0.94),  $\text{K}^+$  (0.87),  $\text{Cl}^-$  (0.98) and  $\text{SO}_4^{-2}$  (0.94).

It must be mentioned that similar results were extracted, while processing hydrochemical analyses data of different periods from the same sampling points.